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Heating Piping & Air Conditioning

DESIGN
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JULY ★ 1943

INDUSTRIAL
COMMERCIAL
AND LARGE
BUILDINGS

361: Journal Section of the American Society of Heating and Ventilating Engineers

BUY WAR BONDS

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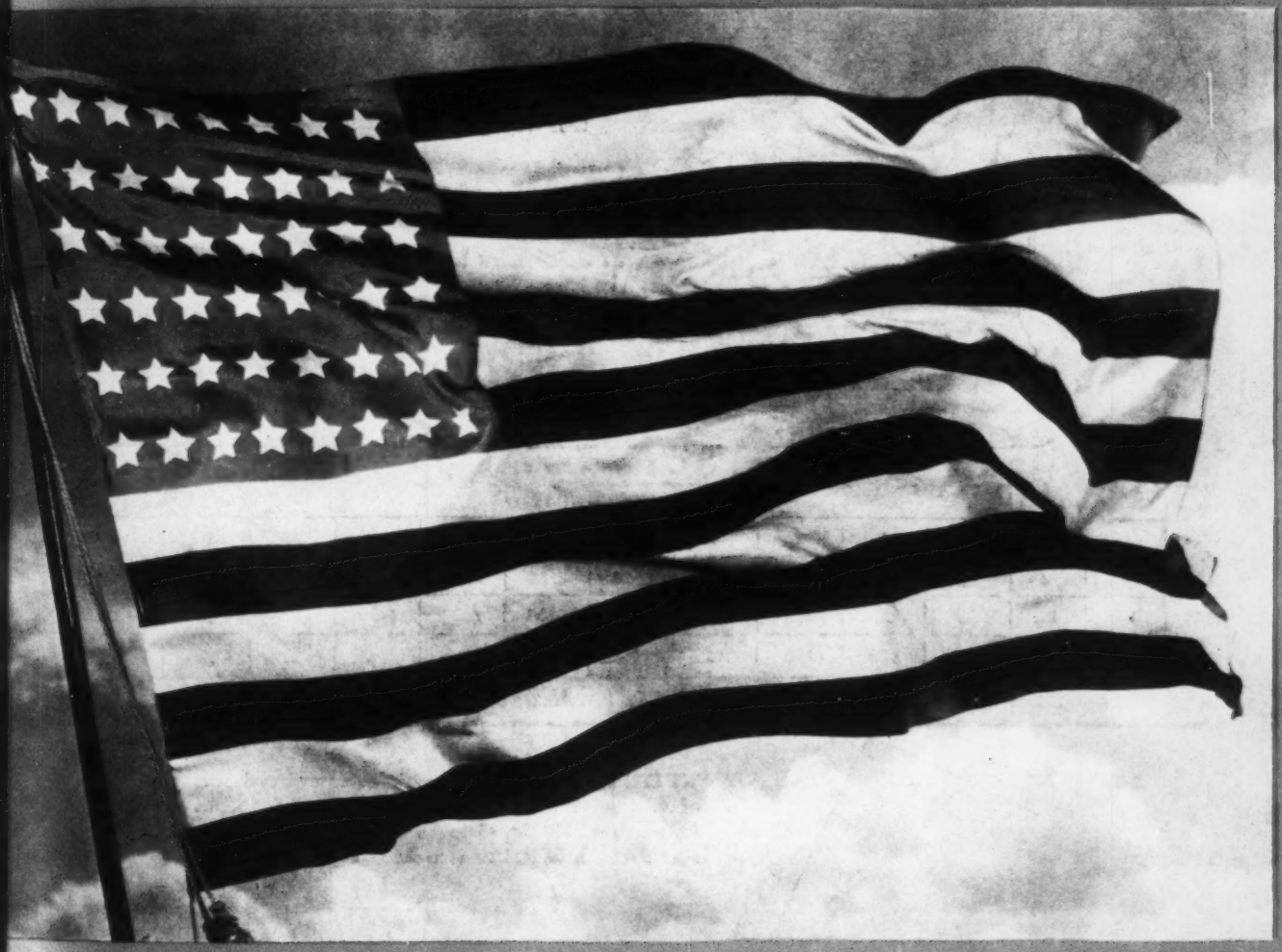
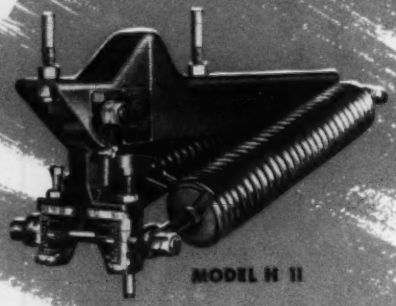


BUY WAR BONDS

CONTENTS . . PAGE 67

3 Genspring Hangers meet LOAD-TRAVEL SPECIFICATIONS!



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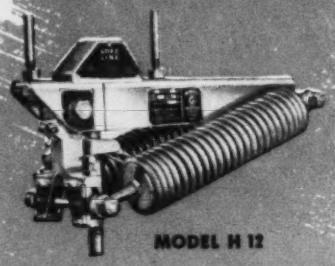

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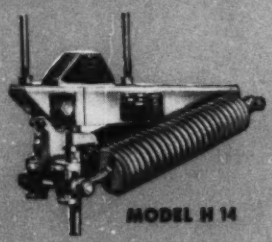

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Only Genspring Hangers offer these highly important features for suspension of high temperature piping:

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- **. . . individually calibrated for each specific installation.**
- **. . . load adjustment features incorporated into the design.**
- **. . . the rated capacity of each model varies with the size of the springs used – the overall dimensions of the hanger remain constant.**
- **. . . minimum head room required.**

LOAD - TRAVEL PRODUCTS in POUNDS and INCHES

MODEL NO.	TOTAL TRAVEL (Inches)		SPRING SIZES											
	Min.	Max.	1A	1	2	3	4	5	6	7	8	9	10	11
H 11	2	4		1190	1620	2300	3390	4775	6185	8150	9765	11765	13995	15305
H 12	1¾	3¼					2770	3900	5056	6675	7975			
H 14	1¼	2½	515	640	870	1230	1820	2555						

NOTE: To obtain Rated Capacity for a given Total Travel, divide the Load-Travel Product by that Total Travel.

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GENSPRING CONSTANT-SUPPORT HANGERS BY **GRINNELL**

WHENEVER **PIPING** IS INVOLVED

The Editor's Pages

ANNOUNCES PLANS FOR INDOOR CLIMATE INSTITUTE

Plans for the formation of an industry-wide cooperative educational program known as the Indoor Climate Institute which will acquaint the American public with the best equipment and methods for producing indoor comfort were disclosed last month by Paul B. Zimmerman, vice president, Airtemp Div., Chrysler Corp., speaking before the National Warm Air Heating and Air Conditioning Association in Chicago. The program, which has been under consideration by a steering committee for several months, will be presented to other leading trade associations at the earliest meetings of these groups.

When the final organization of the institute is perfected as a nonprofit corporation it will be governed by a group made up of individuals representing trade associations in the fields of boilers, controls, warm air heating, oil burning units, gas equipment, stokers, and auxiliary equipment. Additional representatives at large will serve on the board. The institute will be supported by subscriptions from manufacturers of heating units and auxiliary equipment.

The ICI contemplates the issuance of identification seals, the national organization to present them to manufacturers of automatic heating and air conditioning equipment meeting ICI standards and local organizations to present them to installing dealers and contractors handling work in accordance with the best established local practice. It is expected that equipment standards will be established by the various associations now doing a vast amount of research work on problems of this kind and that installation standards will be set according to the best local practice, to meet all safety codes and ordinances.

Local bureaus established under the national program will provide a consulting service for owners, dealers, contractors, architects, engineers, and builders. The local bureau will check plans to see that the heating system is to be installed according to the best known practice, and advise people interested as to necessary changes.

To interest a high type of personnel in heating work in the postwar era, the institute will cooperate with national associations in the issuance of manuals and training courses used in the industry. The educational director of ICI will also seek to establish training courses at colleges, universities, night schools, YMCA schools, and with other educational institutions. It is expected that the splendid work now being done at the University of Illinois and at Michigan State College can be expanded to many other educational institutions.

ARMY NEEDS CONSTRUCTION WORKERS

With a 10 billion dollar war construction program practically completed in the continental United States, the scene for further war building is shifting from areas of preparation to the actual theaters of war, Major General Eugene Reybold, chief of engineers, U. S. Army, told a gathering of several hundred construction men in New York City recently.

"It is not so much a change of pace as a change of emphasis that has occurred," General Reybold declared. "Most of the work on foreign shores of necessity must be done with regular troop units whose personnel and officers are drawn in large numbers from the ranks of construction men."

General Reybold appealed to construction men to continue to exercise their skills in uniform. Through agreement between the Army and the Navy, skilled workers from 18 to 50 years of age may volunteer for induction or enlist in the corps of engineers. Such men will be assigned to general service regiments, aviation engineer battalions and regiments, combat engineer battalions, bridging and penton units, water supply units, and other outfits requiring a high degree of skill.

"Proper thermal environment is civilization's greatest contribution to mankind."—Howard Coonley, director of the conservation division of the War Production Board, in an address on fuel conservation at the semi-annual meeting of the ASHVE.

"Our promise to these men is that we will teach them how to fight with the tools they already know how to use," said General Reybold. "They will be trained at our engineer training centers for the specific jobs ahead. We want them to be just as good soldiers as they are workers—ready for combat as well as for work. We urge those who are interested to go to any U. S. Army recruiting station."

MERCHANT MARINE WANTS ENGINEERS

It is estimated by the War Shipping Administration that by the end of 1943, 2300 newly delivered vessels flying the flag of the United States will be sailing the seas, carrying to our farflung battle fields the 1½ tons of material and supplies which each of our fighting men needs every month. To man these ships, 120,000 men will be needed this year. The greatest need is for men with sea experience of certain skills, including engineers and qualified members of the engine department.

As one example of what has been accomplished by the Merchant Marine of our country, the invasion of North Africa last November may be cited. In that operation, 500 merchant ships, staffed by 20,000 officers and men, were involved. These ships and men carried the 7 tons of equipment and supplies needed by each member of our armed forces to make that invasion successful.

Working conditions and wages in the Merchant Marine have steadily improved since 1935. Wages on Liberty ships now stand at an alltime high and compare very favorably with wages paid in other peace and war industries. In addition to a substantial basic wage, voyage bonuses of 40 to 100 per cent are paid, as well as port bonuses, overtime, and war risk insurance. In the construction of the present merchant fleet, particular care is given to providing the crew with modern, well ventilated, and well equipped quarters. The food is far better than that obtainable by most people on land today. In American and foreign ports the United Seamen's Service, in conjunction with the WSA, has set up a chain of clubs, hotels, recreation centers, and rest homes for the exclusive use of the Merchant Marine.

Service medals and Distinguished Service medals have been designed and presented already to numerous members of the merchant fleet, for they are as much a part of the nation's battle line troops as their comrades in arms of the Army, Navy, and Marines.

Qualified men willing and able to serve their country in this way should get in touch immediately with the local office of the recruitment and manning organization of the War Shipping Administration, the local office of the United States Employment Service, the WSA headquarters in Washington, or with their affiliated maritime union hiring hall.

The Editor's Pages

NAVY HAS NEED FOR MANY SUPPLY OFFICERS

The handling of supplies and accounts in the Navy is a gigantic job. Every variety of stores and equipment must be procured, purchased, inventoried, warehoused, shipped, and distributed as needed. Experts with civilian experience in these phases of handling supplies are needed as commissioned officers in the Navy. A college education is desirable but outstanding men without a degree but with successful experience in this field can be considered.

Purchasing agents with a technical knowledge of raw materials and finished products and men who know specifications and the sources of supply in their field may be qualified to purchase naval supplies and equipment. The age requirements are 32 to 50 years.

Men 28 to 38 years of age with college training, particularly with courses in business administration, are needed as assistants to supply officers at yards and stations. Extensive practical experience in an executive capacity is essential. This should include administrative experience.

Inventory men or managers of warehouses between the ages of 32 to 50, who have been in complete charge of the receipt, storage, preservation, and issue of stores and materials, particularly in the industrial field, may measure up as officers in charge of naval warehouses and supply depots.

In the building of ships and machinery there is a constant problem of insuring the procurement of essential materials. These materials and finished products must reach production lines and shipyards as needed. Executives with purchasing and production allotment experience in the building industry, "durable goods," air conditioning, automotive, refrigerator, or related fields should apply. Because of its importance this billet is limited to capable men between the ages of 35 to 44 years.

A wider age range of 28 to 50 years is permitted for supply officers who know inventory control and stock control. Civilians with broad administrative knowledge of stock control in large industrial plants or department stores may qualify as assistants to supply officers at major naval stations.

The shipping of stores and equipment is a basic naval supply problem. Practical experience must include five or more years in shipping by water, rail, motor, or air. To qualify, men in this field must have had a successful record and know the packing, storage, and protection of goods. They should have a basic and thorough knowledge of space requirements, transportation facilities, rate schedules, tariff, and port regulations.

YORK ICE MACHINERY CHANGES NAME

The York Ice Machinery Corp., one of the nation's largest producers of refrigeration and air conditioning equipment, has announced that the company will be known as the York Corp. as a result of final court approval on a plan of merger and recapitalization. According to S. E. Lauer, president, "the science of refrigeration and air conditioning has far broader applications in the nation's life today than is implied by 'ice machinery,' a term which was at one time applied to all types of mechanical cooling equipment."

The change resulted from a merger with a subsidiary. Aside from the name change and capital structure, the merger affects in no way the company's operations, according to the announcement.

CUNNINGHAM BECOMES CONSTRUCTION MANAGER

T. M. Cunningham has been designated general manager of construction and service of Carrier Corp., according to E. T. Murphy, senior vice president. G. D. Harbin has been designated regional construction manager of Carrier's central region to fill the vacancy created by the transfer of Mr. Cunningham.

The duties of the construction and service manager will include coordination of all field construction work of the corporation; establishment and control of construction policies, methods, and standards; supervision of training programs and the maintenance of proper and adequate construction and service personnel; and maintenance of field construction shop facilities, tools, and machinery.

Mr. Cunningham was the author of articles on duct construction published in the August, 1941, and October, 1942, issues of HPAC.

NEW WELDING LIBRARY AT OHIO STATE

A new library on welding, believed the most extensive in existence, has been established at the Ohio State University, Columbus, Ohio, according to E. N. Manchester, university librarian.

It is the gift of A. F. Davis, vice president and secretary of the Lincoln Electric Co. Mr. Davis received the degree of M. E. in electrical engineering from the university in 1914. Ohio State has a four year course in welding engineering.

CONTAINERS SHOULD BE RETURNED PROMPTLY

Importance of getting returnable containers back to suppliers promptly in order to insure continued delivery of essential chemicals and allied products in wartime has been stressed in a statement by the War Production Board, says the Business Press Industrial Scrap Committee.

The request for prompt return of containers by users applies to steel drums formerly considered non-returnable, fiber drums, slack wood barrels, tight wood barrels, and cylinders. Each user should get in touch with his supplier to find out whether the supplier wants the containers back.

CAN YOU ANSWER THESE QUESTIONS?

Here are a few of the points covered in the many articles published in HPAC this month

1) What are the advantages of standardizing heating, ventilating, and air conditioning equipment for our Navy's fighting ships?
2) What factors must be considered in air conditioning a big blackout war plant?
3) What factors assure a large postwar construction market?
4) What is the trend in the heating of the future?
5) How much oil has the rationing program actually saved?
6) How much fuel can be saved by building temperature control?
7) How do you arrange the piping for cooling welding electrodes?
8) What did they use for piping before the materials employed today became available?
9) How do you select a direct expansion coil for handling all recirculated air?

Where Heat Must Not Fail

Heating Piping & Air Conditioning

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IN THIS ISSUE

Volume 15 **July, 1943** **Number 7**

The Editor's Pages (news and comment).....front section 63

Standardized Heating and Ventilating Equipment for Fighting Ships, by Thomas H. Urdahl and John Everetts, Jr..... 333

Coal Users' Cooperation Asked by Ickes..... 336

Big Building Volume to Follow War..... 337

How Much Oil Did Rationing Save?, by E. P. Heckel..... 338

New 1943-44 Fuel Oil Ration Evidence by Type and Use..... 339

Decentralized Air Conditioning Serves Big Aircraft Factory, by H. M. Hendrickson..... 340

WPB Gives Answers on L-38 Order..... 344

Heating of the Future, by E. N. McDonnell..... 345

Proper Piping Is Important When Cooling Welding Electrodes, by A. L. Munson..... 346

Stoker Makers to Establish Firebox Dimensions; Adopt Statement on Dust Treatment of Coal..... 349

Why a Lower Night Temperature Saves Fuel, by R. A. Parsons... 349

Water Sprayed Direct Expansion Coils—Their Theory and Characteristics, by William Goodman..... 350

Save Fuel to Aid War Effort by Wider Use of Control (NDHA's annual meeting)..... 353

Why Stokers Are Essential in Our Total War Plan..... 354

Camera! (pictures of piping at synthetic rubber plant)..... 355

A History of Piping, by M. A. Hasselmann..... 357

Cost of an Arc Welded Pipe Line..... 359

Electric Air Cleaning Used at Kaiser's..... 360

Equipment Developments .....back section 137

Trade Literature .....back section 146

Useful Information .....back section 151

Index to Advertisers.....back section 168

Journal Section of the American Society of Heating and Ventilating Engineers

Heat Transmission Through Insulation as Affected by Orientation of Wall, by Frank B. Rowley and C. E. Lund..... 361

The Economic Factors in Converting Recirculated Air for Ventilation, by Herbert E. Ziel and Henry Sleik..... 367

Proceedings of Semi-Annual Meeting 1943..... 373

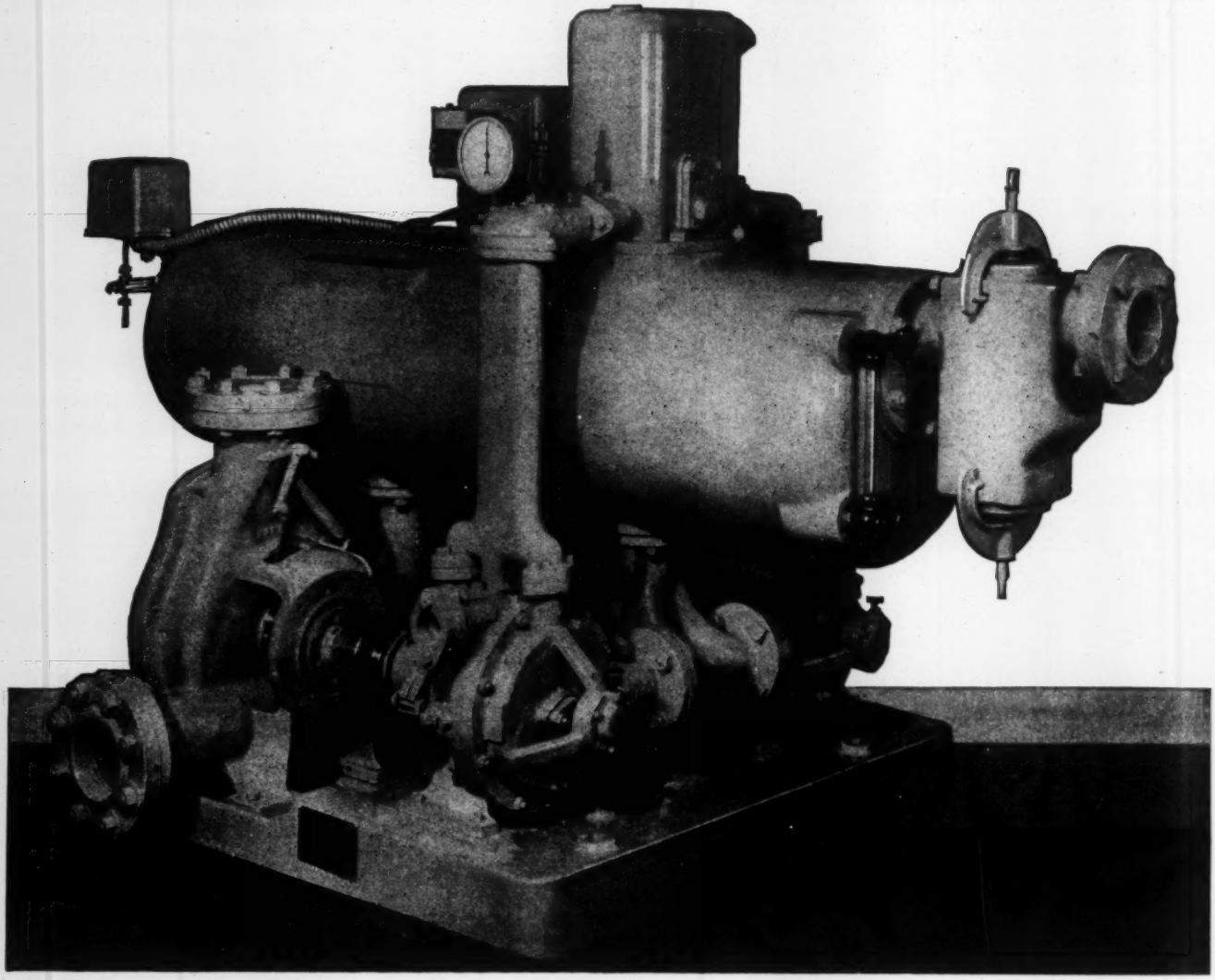
Summary of Local Chapter Meetings..... 388

Candidates for Membership..... 390

Candidates Elected..... 391

Officers, Council, and Committees..... 392

Where Heat Must Not Fail—Install this SAFE Heating Pump!



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More than that, the Vapor Turbine is a most economical pump, for the elimination of electric current does away with current cost, the largest single item in the operation of an ordinary return line heating pump.

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SOUTH NORWALK, CONNECTICUT, U. S. A.

Standardized Heating and Ventilating Equipment for Fighting Ships

By Thomas H. Urdahl, Comdr., USNR
Officer-in-Charge, Air Cond. Section, Shipbuilding Division, Bureau of Ships, Navy Dept.
and
John Everetts, Jr., Lt., USNR
Attached to Air Cond. Section, Shipbuilding Division, Bureau of Ships, Navy Dept.

VENTILATION, heating, and air cooling arrangements and equipment are common to all ships.

The design criteria upon which the extent and quantity of such arrangements and equipment must be provided are likewise common, since they are based largely upon the requirements of the human body to function efficiently under the various climatical and environmental influences which are to be controlled.

The performance and efficiency requirements of such equipment are also common to all vessels—for unless a maximum output per unit of weight and power input is obtained the result reflects itself far beyond the fan or coil into increased wiring, piping, generator capacity, and fuel to the detriment of the primary function of the vessel. When you add to these common denominators the factors of maintenance, ease of replacement, and the present necessity of speed of production, speed in procurement, saving in critical materials, and saving in manpower, there can be no other answer from either the commercial or the military viewpoint than—*standardization.*

The question then arises as to where is individual ingenuity, free enterprise, the continual expounding of the "better mouse trap" idea—all of which are supposed to lead to the necessity for differences in design, dimensions, weights, etc., of the Joe Doaks product as compared with that manufactured by John Smith. The answer is, they have gone to war against the common enemy. Individualities of product have been laid aside just as personalities in the armed forces have been blended into one. The waging of war does not permit each participating unit to carry on in its self-directed, trademarked way. The effort must be regarded as a whole and the burden of cost must fall upon all alike.

When we consider the global character of this war together with the other factors already enumerated and realize the problems of transportation

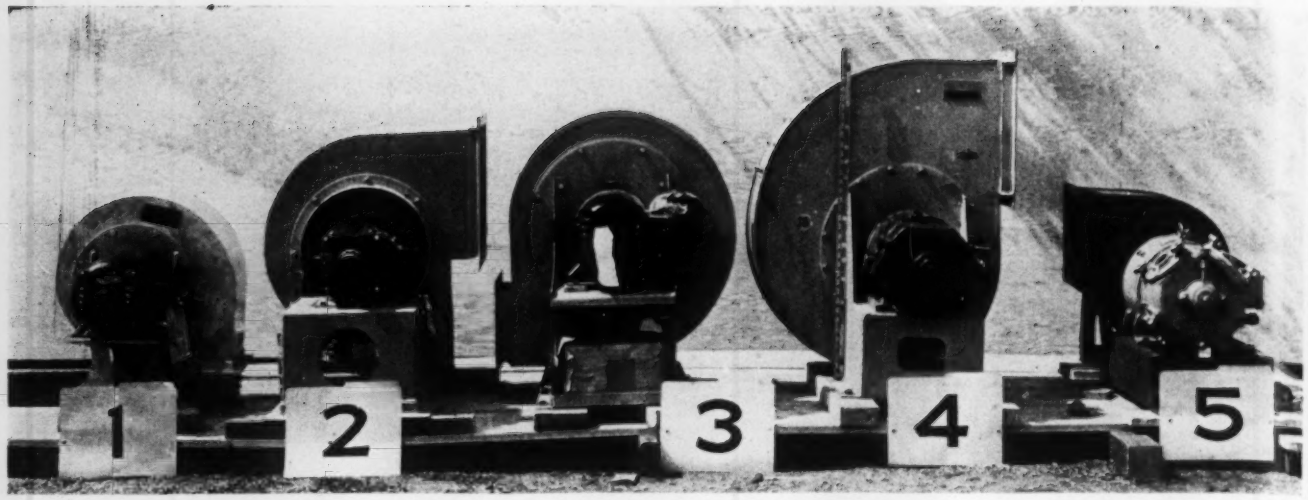


Fig. 1—Each of these fans has the same guaranteed capacity and static pressure. No. 2 is the Navy standardized fan

to distant bases and the implementation of those bases with tools and trained manpower, all possible argument for individuality of design assumes the same significance as does special "Joe Doaks" ammunition for the special "Joe Doaks" gun.

The heating, ventilating, and air conditioning industry has been in the front rank in cooperating with the Navy in speeding the war effort through:

1) Fundamental research in both engineering and physiological fields.

2) Simplification of design practices and their application.

3) Training in design, maintenance, and operation.

4) Conversion of production facilities.

All Contribute to Solution

The problems presented in the development of this program and their application to fighting ships have been successfully met with the wholehearted assistance of not only the leaders of the industry but the rank and file as well. Sales and engineering staffs, the life blood of any manufacturer, have turned their energies to production and the arrangements for the orderly procurement and flow of tools and materials. All of this energy and effort has brought about a transition from chaos and confusion to order and also has led to the ultimate criteria of standardization of the equipment components of heating, ventilating, and air conditioning systems. Standardization is perhaps more involved from the standpoint of the industry than are the four factors first mentioned; however a greater return on the effort expended is realized since standardization has become a "must" to implement the design, production, and maintenance organizations now constructing and operating a vast number of naval vessels, many of which are of identical type but are built in different localities.

Ventilating systems frequently outnumber other vital complementary systems on fighting and auxiliary ships by as much as three to one. Many vessels have as high as 300 separate ventilating systems, few have less than six.

An analysis of fan sizes and capacities prior to standardization indicated 1462 in use, not counting design and dimensional differences between manufacturers. Thus, with only 10 of the leading manufacturers in the industry a total of 14,620 variations is possible. The same is true of heaters, cooling coils, terminals and other component items.

Through standardization the total number of fan types and capacities has been reduced to 30 insofar as dimensions and air deliveries are concerned. The electrical requirements of ac and dc, varying voltages, waterproof and explosionproof, together with varying degrees of permissible temperature rise in motors bring the total variations in construction to the still considerable number of 276. The capacities range from 250 cfm up to 35,000 cfm.

Each Manufacturer Submits Own Drawing

Manufacturers build the various units in general accordance with the Bureau of Ships Standard Type Plans and in exact accordance with applicable material specifications. Each manufacturer submits his own drawing showing the construction in detail, which—when found correct—is approved. Once approved, no further drawings are required for the standard item.

The designer, under nonstandard conditions is faced with two problems: (1) Designing to one manufacturer's equipment dimensions for a group of vessels to be built at various points by different yards. (2) Guessing at an approximate composite which leads to misfits, re-designs, and consequent delays when the final equipment dimensions are known. The latter condition is especially to be avoided, as space on shipboard is at a premium and a "neat" fit is required; also, the economy and efficiency of the original design may be totally upset, resulting in a system being inadequate and

Three to One

Ventilating systems frequently outnumber other vital complementary systems on the Navy's fighting and auxiliary ships by as much as three to one; many vessels have as high as 300 separate ventilating systems, few have less than six. Thus, the advantages of speed and economy in building our ships and repairing battle damage at bases all over the world and at sea can be obtained only by standardization of the ventilation, heating, and air cooling equipment. . . . Comdr. Urdahl and Lt. Everetts stress the importance of the Navy's standardization program, giving the reasons for it and showing its application to fans, preheaters and reheaters, supplementary space heaters, diffusing terminals, etc. Our industry can be proud of its record of cooperation with the Navy; the authors ask our further wholehearted aid in this important standardization work.

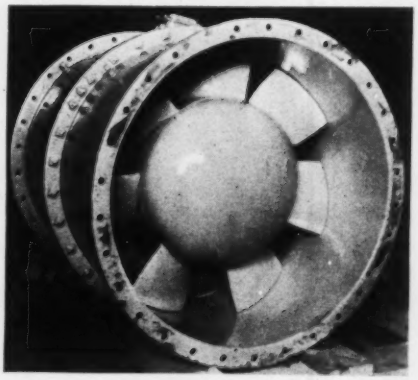


Fig. 2 — Standard Navy type axial flow fan

Diffusing Terminals

Fig. 3—Standard Navy type centrifugal fan

causing the vessel to be delayed while changes are made to bring the system up to its required performance.

The former condition has also led to some manufacturers becoming overloaded with orders while other manufacturers' facilities have been either idle or not operating at the proper production efficiency essential to the conservation of material, manpower, machines and tools. Fig. 1 eloquently illustrates the builders' dilemma with nonstandard equipment. Each of the five fans illustrated has been guaranteed by the respective manufacturer to have the same capacity and static pressure. Fan 2 is the Navy standardized fan. If these five fans were installed in five separate vessels and these vessels later returned to different yards to have the fans replaced because of battle damage it does not take much imagination to realize the amount of time, materials, manpower, and "repair period" for the vessel to change the sheet metal connections, housings, wiring, and foundations to accommodate another nonstandard fan. It must also be remembered that the repair period of a vessel not only takes the vessel out of action for a period of time but makes the crew unhappy as they would much rather fight than eat. It also ties up yard and docking facilities which delays other vessels requiring repairs. In other words, nonstandardization is equally as great a saboteur as the proverbial monkey wrench.

Performance and Quality

In addition to dimensions and capacity, the factors of performance and quality are notably difficult to prescribe and control uniformly without standardization. Fans 1 and 5 of Fig. 1 will be extremely noisy and inefficient. Fan 4 is much too heavy in terms of pounds of dead weight per cfm.

The Navy's requirements of performance and quality provide incentives to equipment designers not only for mere attainment, but to be surpassed. As advancements in design produce units of greater efficiency, specification requirements will also advance. The technological stalemate of the "unsaturated market" should not again be allowed to become the criterion of current quality. Accelerated development has consistently been a byproduct of war but the superior benefits of consistent peacetime development cannot be over emphasized. No present "freezing" of design for standardization can be declared to be the ultimate, though its expediency for rapid and economical production cannot be denied.

The accumulated experience, research, test data, and the abilities of many persons in the Navy and in the related industries have gone into the development and adoption of present heating, ventilating, and air conditioning equipment designs with a view to providing the maximum in quality and efficiency consistent with the dictates of the military characteristics of naval vessels and the successful prosecution of the war.

Three Fan Types

In reaching the proper focal point of research, testing, design, production, distribution, and installation—all of which have equal relative weight in the determination of the final design of a given product—many compromises have necessarily been made; and each compromise is viewed respectively with a natural regret by those of varying technical or economic viewpoints. This, however, must be accepted as basic to any standardization program.

Primary efforts were directed toward standardization of fans, or vent sets as they have long been referred to in naval terminology, since these are used in greater quantity and are more vital than any other component of the ventilation-heating-cooling system. Three general types have been adopted:

1) Axial flow (Fig. 2), 15 sizes and capacities.

2) Centrifugal (Fig. 3), 10 sizes and capacities.

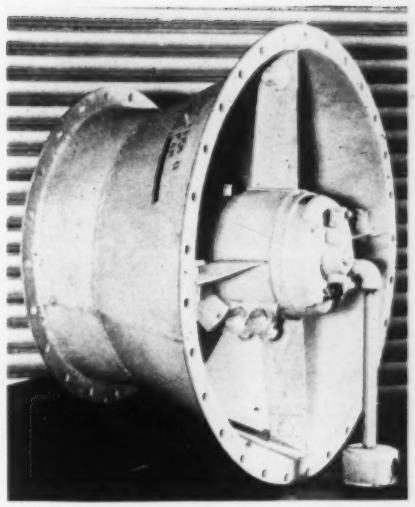


Fig. 4—Standard Navy type propeller fan

3) Propeller (Fig. 4), five sizes and capacities.

The axial flow fan has proved its worth in increased efficiency and reduced dimensions per unit capacity for ventilation of naval vessels. Long a dormant item to be experimented upon in odd moments in the manufacturer's laboratories, it has come forth to be currently used in the ratio of approximately 20 to one over its ancestor, the centrifugal fan. The ever increasing development in the field of applied aerodynamics will make for further improvement in fans and related air handling equipment and in methods of air distribution.

The centrifugal fan still holds a place in design which neither the axial nor propeller fan can fill for certain applications and arrangements of ductwork. The present high performance of the centrifugal fans for naval use will hold their relative position as long as they match the relative efficiency of the axial type.

The propeller fans currently being supplied still leave much to be desired from the standpoint of efficiency and noise. The standardized fabricated

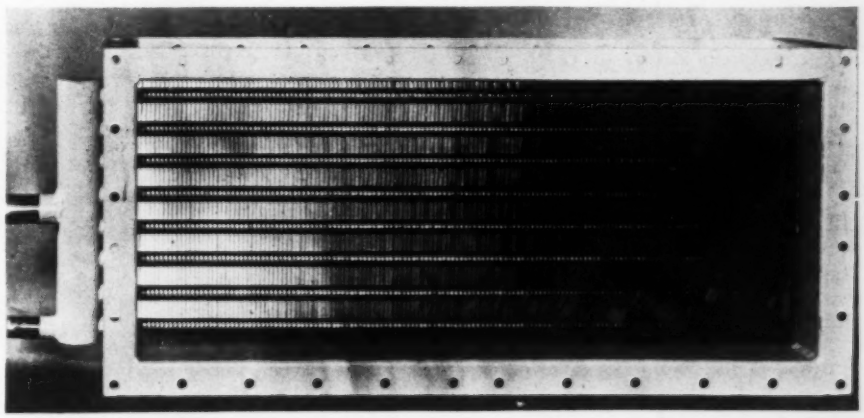


Fig. 5—Standard Navy type ventilation heater (nonfreeze, variable fin spacing)

THE POTENTIALITIES of great eco-

F. W. DODGE CORP. PREDICTS U. S. IS HEADED FOR GREATEST

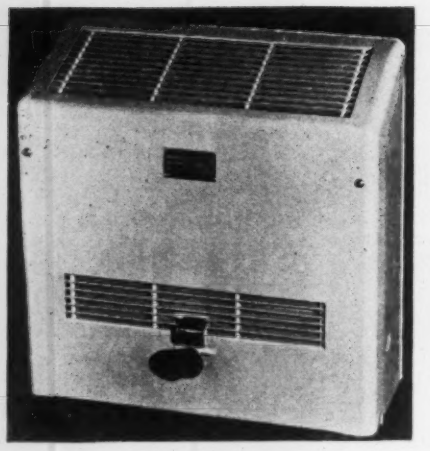


Fig. 6—Standard Navy type convection heater

frame design enables its use for exhaust or supply without adaptor and permits attachment of a limited amount of flanged ductwork where required without elaborate transitions.

Preheaters and Reheaters

Thousands of ventilation air preheaters and reheaters are required, varying in capacity to an even greater extent than fans. Other than in the essential of fixed dimensions, the design standard for heaters has been governed by maximum heat output per pound of copper, resistance to air flow, and anti-clogging characteristics of the fin and tube construction. Service experience has indicated that smooth fins and spacing of approximately 4½ fins per in. is the optimum to meet the latter requirement. As this arrangement is not always possible, a closer spacing with smooth fins is required to meet certain capacities. Rugged construction is, of course, paramount, as gun blast and shock will break loose or weaken the connections to piping or headers. Fig. 5 illustrates the standard Navy type ventilation heater.

Supplementary Space Heaters

Supplementary space heaters present a unique problem. Minimum weight and shockproof construction have dictated the use of the convection heater but the standard operating pressure of 35 psi steam results in air temperatures leaving the convector too high to avoid stratification, with the result that compartments were not uniformly warm from deck to overhead and steam was wasted. The variable bypass damper has proved a satisfactory solution to lower leaving air temperature for either steam or high temperature water, (220-240 F) convectors.

The standard unit, Fig. 6, is designed for maximum heating of the living space at minimum weight with protective grilles designed for minimum air flow restriction.

Diffusing Terminals

Service experience and tests of the several commercial types of diffusing terminals led to the development of the Navy standard diffusing terminal illustrated in Fig. 7. This unit offers the advantage of even distribution of air with even diffusion around the periphery by means of turning vanes which deflect the air stream normal to the plaque and results also in a high degree of aspiration.

One standardized item which is least known is the vaned elbow. A substantial reduction in friction and air noise created by turbulence is accomplished through its use. Steel sections rolled to size and curve requirements are assembled in jigs, bound with an angle frame, welded, and galvanized. Restricted space requirements have resulted in an ever increasing tendency toward rectangular ducts for which vaned turns are practically mandatory to achieve efficient design at minimum weight of duct material.

Simplifies Materials Allocation

Another, and by no means minor, blessing of standardization is derived through the simplification of the process of allocating controlled materials and in the scheduling and progressing of components to meet shipbuilding schedules. A review of the procedures now involved in allocation of material and the scheduling of deliveries gives a slight impression of the magnitude and complications which would be experienced if a greater diversity of sizes and types were to prevail. Paperwork might then truly outweigh the effort and material in manufacture.

The active participation of the heating and ventilating industry and its support of standard methods and equipment items over the past year and a half has led to the complete accomplishment of a program which seemed impossible, and indeed would have been impossible without such active support.

What Standardization Means to All of Us

In conclusion, the several advantages derived from standardized equipment as they accrue to the various activities involved are: (1) Speed in production. (2) Facility and accuracy in design and planning. (3) Uniformity of installations. (4) Simplicity of distribution and identification. (5) Interchangeability.

To the manufacturers the advantages are: (1) Line production for maximum man hour and machine efficiency. (2) Elimination of individual type drawings. (3) Simple cost and material accounting. (4) Simplification of subcomponent procurement such as motors, controls, tube and sheet material. (5) Reduction of design and sales engineering.

The advantages to maintenance and repair activities are: (1) Interchangeability of like parts between systems and vessels. (2) Speed of replacement. (3) Savings in man hours and materials. (4) Facility of distribution and identification. (5) Ability to procure and stock against possible future needs of war damage. (6) Reduction in number of spare parts required on shipboard.

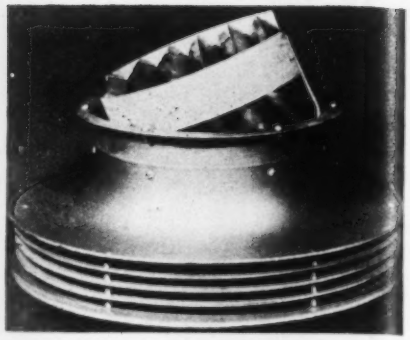


Fig. 7—Standard Navy type diffusing terminal

The advantages to the taxpayer are: (1) Direct reduction in unit item cost through line production. (2) Elimination of indirect pyramiding labor and material cost items involved in design and installation. (3) Reduction in handling and administrative costs.

The only apparent disadvantages of standardization for the fighting ship: It did not begin soon enough . . . it has not been carried far enough.

COAL USER'S COOPERATION ASKED BY ICKES

One of the most vital factors in next winter's coal supply picture is consumer cooperation.

Solid Fuels Administrator Harold L. Ickes has said that "Coal must be ordered and users must take delivery as the coal can be supplied. Industry must maintain production by ordering coal now and providing storage space for adequate supplies." He has advised industrial users to:

1) Contract for or order coal as soon as possible.

2) Allow the dealer fullest possible latitude as to size and kind of coal, shipping or delivery schedules, and type of transportation equipment used.

3) Build stockpiles up to the following levels: For essential war industries, from 90 to 120 days' supply; for other industrial users, from 60 to 90 days' supply.

Mr. Ickes urges domestic bituminous coal users (householders, small industries, and all who purchase coal through retail dealers) to order coal now and store as much this summer as local conditions permit; and to cooperate with the dealer in allowing him the fullest possible latitude as to size and kind of coal and delivery arrangement.

F. W. DODGE CORP. PREDICTS U. S. IS HEADED FOR GREATEST PERIOD OF PROSPERITY, WITH SEVEN FACTORS LEADING WAY

Big Building Volume to Follow War

THE POTENTIALITIES of great economic expansion and prosperity for the United States, with its great resources, technological development, enlarged productive facilities, high level of income, and outstanding position in world affairs, are enormous, according to Thomas S. Holden, president of F. W. Dodge Corp., in a review of some of the corporation's findings on the postwar construction market. With sound policies and good management, with reference to our domestic affairs and to international relationships, this country should enjoy hereafter a greater prosperity than it or any other country has ever had, he believes.

"Such prosperity cannot be achieved without enormous construction activity. Careful appraisal of long range prospects indicates that the decade following the war should have a larger volume of construction than any previous decade in our history. Immediately after the war, government will be obliged to adopt policies that will encourage wide scale investment in new enterprises in order that we may carry our big debt load attributable to the war, and in order that we may maintain reasonably full employment and utilize our vastly improved and augmented industrial plant capacity," Mr. Holden said.

The principal potential expansion factors, as listed by Mr. Holden, are:

1) Revival of the automotive industry—The transformations in modes of living and community patterns wrought by the automobile have not been completed. Much is yet to be done in developing bus and truck terminals, hard surfaced highways, revamping street and open space patterns of cities and towns.

2) Aviation—Commercial aviation, including fast freight service, is due for a vast expansion. The private plane may become a really important transportation factor. Whether this development in transportation, practically certain to come on a large scale, will become as great a stimulus to general industrial and business expansion as railroads and automobiles have been remains to be seen. In any case, hangars of many varieties and sizes, airports, passenger and freight terminals, and many as yet unknown accessory buildings will be required.

Conducting Product Research

3) Light Metals and Synthetic Materials—War needs have caused enormous expansion of aluminum production; they have practically created a magnesium industry; they have brought into being new plastic materials and expanded production of others; and have created a synthetic rubber industry. Producers of all these materials are conducting product and market research in peacetime uses of these goods. These materials will be used in industrial products, airplanes, automobiles, household conveniences, art objects, and in many other ways. Their development as structural materials may conceivably revolutionize construction methods, architectural styles, and furniture design. It is very difficult to see any limits to the expansion possibilities of these materials, newly available in vast quantities at low prices.

4) New Construction Materials and Methods—New materials and new construction methods, producing greater values per building dollar, will inevitably increase demand for low cost buildings of every classification, particularly houses. War construction requirements, with the paramount needs of speed and economy in use of scarce materials, are daily modifying traditional design ideas and construction procedures.

Housing Revival to Resume

Among other things, the makers of prefabricated houses have for the first time found in the war housing program quantity orders for houses, creating an opportunity for practical development of techniques and demonstrations of potentialities that did not hitherto exist. Undoubtedly, such developments will have some lasting effects upon construction methods and procedures, though the importance of the prefabricated house itself as a factor in the future housing market is still problematical.

In any case, many of the technical developments of the war period will persist. To the extent that they will provide better buildings for less money, they will contribute largely to expanding the construction market.

5) Housing—The housing revival of the late 1930's, interrupted during the period of war restrictions except for buildings in the war housing classification, will doubtless be resumed. In part, the housing program will make up deficiencies of the last depression period. Its continuation will depend upon the degree of general prosperity (high national income and full employment) the country will enjoy. If national income averages over 100 billion annually in the 1940 decade, as seems highly probable, housing demands will be very great and will continue for an extended period. There will be a much greater demand, proportionally, for houses to cost over $6000 than in the 1930 decade, not only because there will be some surpluses of lower priced houses directly after "V day," but also because higher national incomes mean more families moving into higher income brackets and demanding better houses than they lived in before. The expanded housing market will be largely a market for private building and investors. The possible extent of any government housing program is purely conjectural at this time.

6) Urban Redevelopment—Redevelopment of blighted urban areas, talked about a great deal during the past decade, is more than likely to develop into real large scale programs. A number of people are advocating that this should be done on a national scale, with subsidies for local communities by the federal government. Other people, equally impressed by the necessity of doing this job on a large scale, believe that it can be done and done more soundly through local initiative and private investment; to this end several states have enacted enabling legislation to encourage private initiative and private investment.

Need for Urban Redevelopment

Urban redevelopment would create large scale projects, including housing, commercial and industrial buildings, and public facilities. Some projects would call for immediate demolition of old buildings and replacement with new ones. Some would combine modernization of existing buildings, new construction, and gradual replacements of old buildings. The urgent necessity for urban redevelopment is based upon the need to restore the balance between central districts and outlying areas, to recreate real estate values, improve the security underlying mortgages, and improve the financial status of cities.

7) Public Works Reserve—Federal, state, and local governmental agencies customarily responsible for planning and executing public improvement projects have been obliged, like private investors, to postpone those projects of civilian character which would, under other circumstances, have been carried out this year. Regular improvement projects so postponed during the war period thus become part of the deferred construction market. These agencies also are engaged in developing long range programs for projects to take care of the future needs of their respective communities.

How Much Oil Did

E. P. HECKEL GIVES RESULTS OF A STUDY

IN ORDER to obtain comparative data for the instruction of fuel oil users and to determine actual results of the fuel oil conservation efforts for the 1942-43 heating year, a detailed checkup has been made of all of the fuel oil applications, the rations originally allocated, and the supplemental oil issued, up to May 11, 1943, for a community that has a population of some 12,000 and is suburban to Chicago. Many of the homes in this residential suburb use hard fuel or gas for space and water heating. Of the total number, 898 dwelling units use oil for heating.

It is believed that the average conditions and figures as determined by the statistics gleaned from this survey may be representative of those that could be expected in comparable communities and weather zones. In this connection, it is of interest that preliminary figures for a random selection for this community agreed closely with the final results.

The pertinent data accumulated from the fuel oil application records is summarized in Table 1. This table gives the totals for number of units; floor area; certified oil delivered September 1, 1941, to October 1, 1942; number of occupants declared; oil ration per basic processing regulations for the 1942-43 season; estimated increase in ration due to the 10 per cent increase in value allowed on the period 3, 4, and 5 coupons; extra allowances made by the local rationing board to provide for hardship cases; total gallons; and gallons of total oil rations applicable for water heating.

Table 1—Comparison of total fuel oil consumption before and after rationing

	Private dwelling units	Commercial units	Trailer units	Combined totals
Number of units	898	64	113	1,075
Floor area, sq. ft.	1,292,885	451,600	21,183	1,765,668
Declared oil consumption, 1941-42 season, gal.	1,617,191	322,869	48,466	1,988,526
Number of occupants declared	3,422	.....	302	3,724
Oil ration according to basic process, 1942-43 season, gal.	1,270,542	244,754	30,988	1,546,284
Estimated increase in ration due to 10 per cent increase in value allowed on 3rd, 4th and 5th period coupons, gal.	50,822	9,790	1,240	61,852
Extra allowance to cover hardship cases, by local ration board, gal.	99,084	24,610	5,180	128,874
Total 1942-43 gal.	1,420,448	279,154	37,408	1,737,010
Estimated proportion of the above allowances applied to water heating, gal.	52,182	161	700	53,043

These figures are broken down into three classifications of consumers—private dwelling units, commercial units, and trailers. The total declared oil consumption of all three classified users is shown as 1,988,526 gal. The comparable total consumption for the 1942-43 season under rationing is 1,737,010 gal.

Some question might be raised as to the accuracy of the figures for estimated increase in rations due to increase in value of period 3, 4, and 5 coupons. The amounts shown in the table were estimated to include all probable extra oil, over and above the original ration quantity, that was obtained by the coupon holder due to the extra allowance of 10 per cent made by OPA to the holders of 3rd, 4th, and 5th period coupons. In each case an amount equal to 4 per cent was added to the original ration issued, as a fair average allowance to cover this uncertain value. This may be considered as a reasonable maximum figure. It should be clear to all who have had some experience in the oil rationing program that all ration holders did not benefit equally. Some with large fuel tanks were penalized by declared inventory on hand at the time ration coupons were issued, and some had deliveries made prior to valid dates of the coupons and thus they lost such benefits. Others, recognized as hardship cases, had valid coupons issued to them in exchange for non-valid, at face value, particularly period 2 for period 3, to tide them over to the next period without any share of the increase value benefit. All in all, it appears that the statistical information as shown and as developed can be accepted as reasonably correct.

The degree days for the 1941-42 season totalled 5,736 from October 1, 1941, to September 30, 1942. This is exclusive of the months of July and August, which are not considered heating months and therefore are not included in the Annual Meteorological Summary as issued by the U. S. Department of Commerce, Weather Bureau, Chicago.

The normal degree days for Chicago are given as 6,423. The actual experienced degree days, October 1, 1942, to May 31, 1943, total 6,656. To this figure we should add the degree days yet to be experienced, for June and September, 1943, to have comparable periods for comparison. What this will add to the known 6,656 figure is problematical. We may reason that it may be equal to the normal for these months, which is 163 degree days; this sum may be added to arrive at a probable total of 6,819 for the 1942-43 season.

Subject to the correction of the 6,819 degree day figure, the total heating demand of the 1942-43 heating year may exceed that of the previous heating year by 19 per cent and exceed the normal by 6.2 per cent.

Results Achieved by Rationing

The figures in Table 2 represent a brief analysis and breakdown of the statistical data shown in Table 1.

The reduction in actual oil consumption for space and water heating is shown by comparative figures which will be found self explanatory. It seems rational to believe that a saving of 196,743 gal of oil by residential users, 43,715 gal in commercial heating, and 11,058 gal by trailers would not have been accomplished without the wartime restrictions and

Save 0.4 Gal per Sq Ft

As we near the end of the OPA heating year—September 30—it is possible to determine rather accurately how much oil was saved during the first season of rationing. Mr. Heckel has analyzed all of the users of fuel oil for heating in an entire residential community, and presents his most interesting results here.

The data indicate that under rationing and with the cooperation of consumers, a saving of 0.4 gal per sq ft of floor area per season has been conserved by private dwelling units. Some of the saving may of course be attributed to lower than comfortable temperatures, shutting off non-essential space, etc. Some of it, too, is due to economy measures which would have been advisable even if oil supplies were not restricted.

Mr. Heckel, of E. P. Heckel & Associates, is a member of HPAC's board of consulting and contributing editors and has been active in rationing work with his local board.

Table 2—Comparison of oil consumption before and after rationing on square foot and percentage bases

	Private dwelling units	Commercial units	Trailer units
Average floor area, sq ft	1,440	7,050	187
People per unit	3.8	....	2.67
Oil consumption, gal per sq ft. of floor area, 1941-42 season	1.25	0.715	2.28
Anticipated max. oil consumption, gal per sq ft floor area, 1942-43 season	1.1	0.62	1.78
Total reduction in fuel oil consumption, 1942-43 compared to 1941-42, gal	196,743	43,715	11,058
1942-43 oil consumption compared to 1941-42, per cent	88	85	77.5
1941-42 oil consumption, weighted to conform with increased 1942-43 degree days (× 19 per cent) = probable gal	1,924,457	384,214	57,674
1942-43 oil consumption compared to weighted 1941-42 consumption, per cent	74.5	72.5	65
Oil conservation for 1942-43 season when compared to 1941-42 weighted basis would equal, gal	504,009	105,060	20,263

Rationing Save?

OF ALL OIL CONSUMERS IN A COMMUNITY

the oil conservation program; and certainly not without the general, wholehearted cooperation of a majority of all fuel oil users.

To accomplish the results shown, it was very obviously necessary that the consumers of fuel oil for heating had to adjust themselves in many ways to reduced comfort standards, restricting the ordinarily maintained indoor temperatures to 65 deg and downward instead of maintaining the previous customary temperatures of 70 deg and upward; closing off rooms needed but not absolutely necessary, etc. Many equipped their windows with storm sash, applied weatherstripping, and insulated their homes to reduce heat transmission and air infiltration losses. These are things they should have done anyway, but probably would not have done except under present circumstances and need.

While the actual residential consumption of oil for heating was reduced from the previous average rate of 1.25 gal per sq ft of floor area to 1.1 gal, it represents a respectable total of 196,743 gal saved and a consumption for the 1942-43 season that is 88 per cent of the previous season —despite the fact that the present season has been some 19 per cent colder and would have demanded approximately 19 per cent greater oil consumption than last season if the customary normal indoor conditions of temperature had been maintained.

By extending this thought and consideration, it seems quite reasonable to speculatively determine what the overall oil conservation and consumption restricting program accomplished. We may reason, and logically so, that had these conservation efforts not been in force and the need recognized by government and consumer, the consumption of fuel oil for space heating during the current season would have been increased over last in almost direct proportion to the degree days increase over last season. Individual sacrifices of comfort insofar as heating is concerned and lowering of home temperatures would not have been considered necessary. Obviously the oil consumption rate instead of being reduced from 1.25 gal to 1.1 gal, as was the case, might easily have been increased some 19 per cent or, from 1.25 gal to approximately 1.50 gal this season. Accepting this as a probable that could have developed, the net accountable oil saving in this case creditable to the oil conservation program may be considered as the difference between 1.50 gal estimated probable consumption and the actual of 1.1 gal, a difference of 0.4 gal per sq ft per season—a very commendable and worthwhile accomplishment.

NEW 1943-44 FUEL OIL RATION EVIDENCE BY TYPE AND USES

(From OPA fuel oil industry letter No. 11)

Type of Ration Evidence	Form Number	Description of Ration Evidence	Total Value of Coupon Sheet in Gallons (at par)	Uses of Evidences
Class 4 coupon sheet	R-1137 to R-1146	55 1-unit coupons = 550 gal 11 10-gal coupons = 110 gal 48 change-making coupons = 140 gal 114 total coupons on sheet	800	All heat and hot water rations between 300 and 500 gal, and between 500 and 4,000 gal if storage capacity is less than 100 gal (Applies mainly to space heaters)
Class 5 coupon sheet	R-1147 to R-1156	30 5-unit coupons = 1,500 gal 6 50-gal coupons = 300 gal 36 change-making coupons = 200 gal 72 total coupons on sheet	2,000	Heat and hot water ration between 500 and 4,000 gal if storage capacity is greater than 100 gal
Class 6 coupon sheet	R-1157 to R-1166	30 25-unit coupons = 7,500 gal 6 250-gal coupons = 1,500 gal 36 change-making coupons = 1,000 gal 72 total coupons on sheet	10,000	All heat and hot water rations between 4,000 and 20,000 gal, and between 20,000 and 50,000 gal if certificates are not requested
Fuel oil deposit certificate	R-1170	A certificate issued for a definite gallonage, which is deposited by consumer in bank.		All rations over 50,000 gal, and between 20,000 and 50,000 gal if certificates are requested. Consumer draws checks against his bank account.

Class 3 sheets will continue in use for small heating rations and for non-heating rations.
Ration checks will be used by all participants in ration banking.

The air conditioning equipment is on platforms above the trusses, with catwalks which facilitate operation and servicing

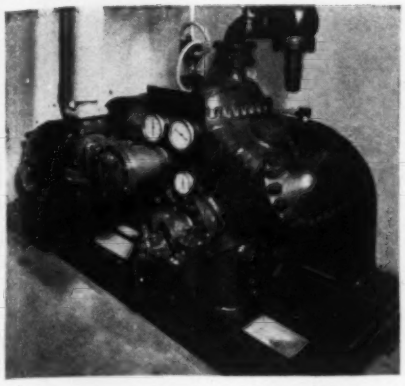
Decentralized Air Conditioning Serves Big Aircraft Factory

H. M. HENDRICKSON ANALYZES VENTILATION, HEATING, AND AIR CONDITIONING INSTALLATIONS AT LARGE WEST COAST PROJECT

ONE of the largest completely blacked-out factories in the United States is situated on the west coast, in a region classed as a "combat area" by the military. It is a tribute to the vision of the government and industrial leaders who planned the Douglas Aircraft plant at Long Beach, Calif., that the windowless feature was incorporated in the design more than a year before the beginning of hostilities with Japan. Once the windowless construction was made a requirement, the necessity for air conditioning became evident. As the windowless feature eliminates any natural lighting, the artificial lighting load became enormous. Consequently, refrigeration was necessary to offset the heat from the lights, to take care of the large connected horsepower load required for manufacturing processes, and the heat load from the many people.

In a windowless building, ventilation is first in importance, as without plenty of air satisfactory working conditions cannot be maintained. Next in importance comes cooling and then heating, as far as the manufacturing buildings are concerned. For the office buildings the importance of heating versus cooling is reversed; that is, heating is of somewhat greater importance than cooling for satisfactory working conditions throughout the year.

The ventilation was decentralized to a marked degree by providing each building with a number of independent fan systems. A direct bomb hit on a ventilating unit thus could only affect a small section, and would not put the entire building out of commission. Furthermore, it was required that all ventilating ducts and equipment in the factory buildings be in roof spaces above the bottom chords of the trusses. It was necessary to leave all of the space below the trusses clear for manufacturing processes, including the movement of cranes. Therefore, the size duct that



One of the 60 ton refrigeration compressors as used in the factory and office buildings

For Decentralization

There isn't any argument about whether or not air conditioning promotes manufacturing efficiency; in fact, in the post-war period when material restrictions are removed, many a plant without air conditioning is going to be obsolete, economically speaking. For many factories, of course, air conditioning not only is highly desirable but is absolutely essential —such as the case of Douglas Aircraft's windowless project described here by Mr. Hendrickson, assistant branch engineer of the York Corp.

There is, however, argument as to the proper technique of air conditioning a particular plant. Circumstances alter cases, and the air conditioning designer has innumerable factors to consider. The project described here uses a decentralized layout of direct expansion assemblies, as contrasted with a central refrigeration plant from which chilled water is piped to the air treating equipment located throughout the plant. The author explains the advantages of the method, and compares the two schemes in his conclusions.

could be run through the truss members largely determined the number of fan stations. These fan stations incorporate a supply fan, cooling coils, heating coils, and a filter bank. They are on platforms approximately 25 ft wide by 30 ft long, just above the bottom chords of the trusses.

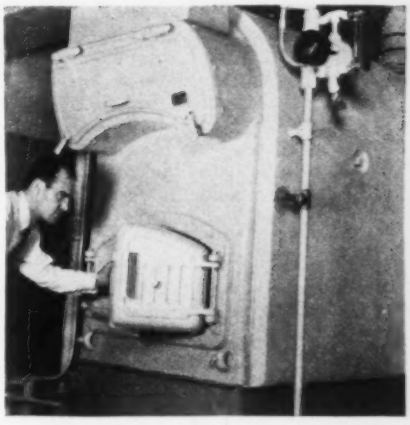
Unitary Cooling Setup

The preliminary plans contemplated at least two boiler and refrigerating plants for each important building, with up to a maximum of five equipment rooms for the largest building. These equipment rooms were located at the ground level with cooling and heating coils at each fan station. Direct expansion, surface cooling coils were selected for cooling, in preference to chilled water coils, to take advantage of the lower horsepower per ton possible with the higher suction pressure operation that can thus be obtained. With direct expansion, the refrigerating machines operate at higher suction pressures to maintain the desired 40 to 45 F coil temperature.

As the design progressed, however, and it was found that approximately 60 tons of refrigeration would be required per fan station, the superiority of a completely unitary cooling setup became apparent. The development of high speed, dynamically balanced, "Freon-12" refrigeration compressors in the larger sizes by various equipment manufacturers fitted perfectly into the picture. It was found that a 60 ton compressor and evaporative condenser could be located on the same platform with the fan, filters, cooling coils, and heating coils. With the dynamically balanced refrigerating machines, vibration is not a serious problem, and the fan platforms were made to accommodate the additional equipment with but a small amount of strengthening and enlargement. The advantages of these unitary refrigerating systems in eliminating large and long refrigerant liquid and suction lines were numerous. The cost of piping, pipe insulation, and refrigerant charge was greatly reduced. The heat loss from refrigerant lines was practically eliminated, and the danger of refrigerant loss from leaks was reduced to a minimum, because of the short coupled piping hookup. Furthermore, in case of a direct bomb hit on a refrigerating unit, the refrigerant loss would be comparatively small, since only the charge from one or two small systems would be lost.

It was not found desirable, however, to place the heating boilers in the roof spaces above the bottom chords of the trusses. Boiler rooms were provided at the ground level, and one or more boiler plants were furnished for each building according to size. To provide maximum flexibility, the larger buildings were provided with three to five boiler rooms

This type of diffusing air outlet is used in the office spaces



The heating boilers, also decentralized, are fired with gas

advantageously spaced to cut steam and return piping sizes to a minimum. All boilers are the return tubular type with gas burners, and are arranged for future use of oil if necessary.

Blast steam heating coils are used, with the main heating coils in the outside air inlet at each fan station. All ventilating ducts along the outside walls are provided with booster heating coils, but inside zones have no additional heating other than that provided by the main heating coil in the outside air inlet. The boilers are over-sized to provide ample capacity for processing steam and for quick heating up from a cold building.

Factory fan stations vary in capacity from 30,000 to 40,000 cfm each, and are single fan systems. The fan supplies air to an overhead distribution system, and also draws the air back through the return duct system to the plenum chamber which houses the filters, cooling coils, heating coils, and dampers.

Air is supplied directly downward through four way deflecting grilles, placed on approximately 25 to 30 ft centers, at a velocity of around 1000 fpm. Return ducts are brought down to within 7 ft of the floor around the outside walls and at certain inside columns where space is available. Return ducts to a point close to the floor were considered necessary to keep the heated air down at the working plane in winter. Also, they aid immeasurably in stratification during the cooling season, as no attempt is made to cool the upper part of the building. The cold air is kept at the floor in summer and there is no disturbance of the hot stratified air at the ceiling as there would be if returns were taken at the ceiling. This design saves considerably in operating costs for both summer and winter operation.

Design Conditions and Load

The factories were designed for 68 F dry bulb inside, with 40 F dry bulb outside conditions in winter; and 80 F dry bulb and 48 per cent relative

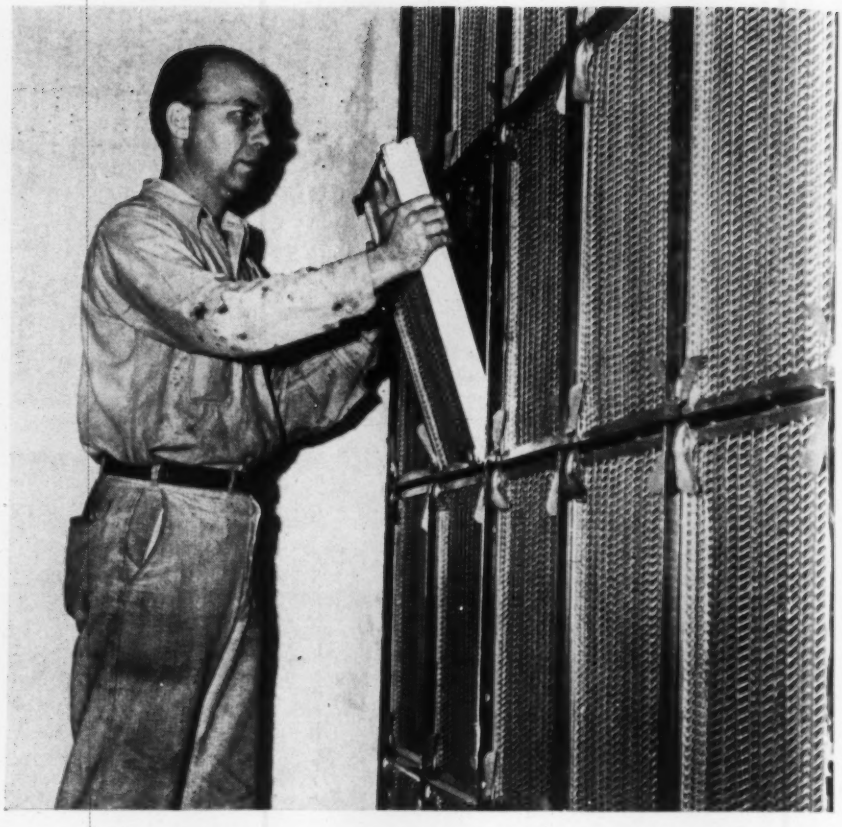
humidity inside, with 90 F dry bulb and 70 F wet bulb outside conditions in summer. The internal sensible load from motors, lights and people is the largest single factor in the cooling load. On a typical factory building, the latent heat load figures only 8.7 per cent, the leakage 21.6 per cent, the outside air sensible load 16.3 per cent, and the fan motor heat 7.6 per cent; whereas the internal sensible load from motors and people amounts to 45.8 per cent of the total refrigeration requirements.

The required lighting intensity in the factory buildings is maintained with 3.5 watts per sq. ft of lighting using mercury vapor lamps. Each globe is equivalent to about a 750 watt mazda lamp, and the life of the lamp is approximately 4000 hr. The factory buildings are of steel frame construction with asbestos protected, corrugated steel siding, having a lining of 1 in. insulating board. The roofs are also lined with 1 in. insulating board. The floors of the factory buildings are concrete directly on the ground.

Control of the Equipment

All equipment stations are in the truss work and are connected with an extensive system of catwalks, making it unnecessary to descend to the floor level when servicing equipment at the various stations. The evaporative condensers at each fan station handle about 10,000 cfm each. The outside air intake duct for each evaporative condenser is dampered so that it can be shut off during ventilating operation without cooling. Then doors in the casing can be opened so that the evaporative condenser fans can be used to exhaust air from the truss spaces. The supply fan is started manually from a pushbutton and must be in operation before the electric controls will permit the refrigeration apparatus to start. An ingenious drum switch is provided at each unit for changing the control positions for the cooling equipment. Five positions are provided: off, exhaust (evaporative condenser fan only), test (evaporative condenser fan and pump), hand (all refrigeration apparatus on manual control), and automatic (refrigeration apparatus under thermostatic control).

The automatic control systems are pneumatic, and are comparatively simple for the factory buildings. A pneumatic summer and a pneumatic winter thermostat are centrally located about 6 ft from the floor for each fan station. In addition, a pneumatic winter thermostat is provided for each steam booster heater in the zones along the outside walls. The summer thermostats are set at 80 F and the winter thermostats at 68 F; they are interlocked so that the heating and cooling cannot be on at the same time in any one system. The refrigeration machines have two capacity steps, starting up at half capacity and only going to full capacity as the cooling load increases to maximum. The steam control valves are pneumatic and the electric refrigeration controls are interlocked with the pneumatic thermostats by means of pneumatic-electric relays.



A typical bank of cleanable type air filters as used in the factories

On the smaller factory buildings, the outside and return air dampers are manually controlled. On the larger factory buildings, these dampers are pneumatically controlled by an outside air, dry bulb, thermostat, and a humidistat. This thermostat is set to use maximum outside air between 60 and 80 F dry bulb outside temperatures. Under heating conditions, when the outside temperature starts to go below 60 F dry bulb, the outside air damper closes to a minimum setting and the return dampers open wide. Under cooling conditions, as the outside temperature goes above 80 F dry bulb, the outside air dampers again close to minimum and the return dampers open wide. Between 60 and 80 F dry bulb, full advantage is taken of the cool outside air for ventilation.

A limit humidistat is connected in series with the outside air thermostat to close the outside air dampers when the outside relative humidity goes above 65 per cent. This was necessary because of the night coastal fog condition, which causes water precipitation on the filters if too much outside air is used. One set of outside air controls is provided for each group of four to five fan systems.

The pneumatic air supply is taken from the main building compressed air service, and is reduced to 15 psi at each fan station. A large auxiliary air receiver is provided at each one or two fan stations for a reserve of low pressure control air. No control air compressors were required, which fact reduced the cost of the control system considerably. The pneumatic controls for the entire project ran approximately 2½ per cent of the total cost of the heating, ventilating, and air conditioning.

Office and Cafeteria Buildings

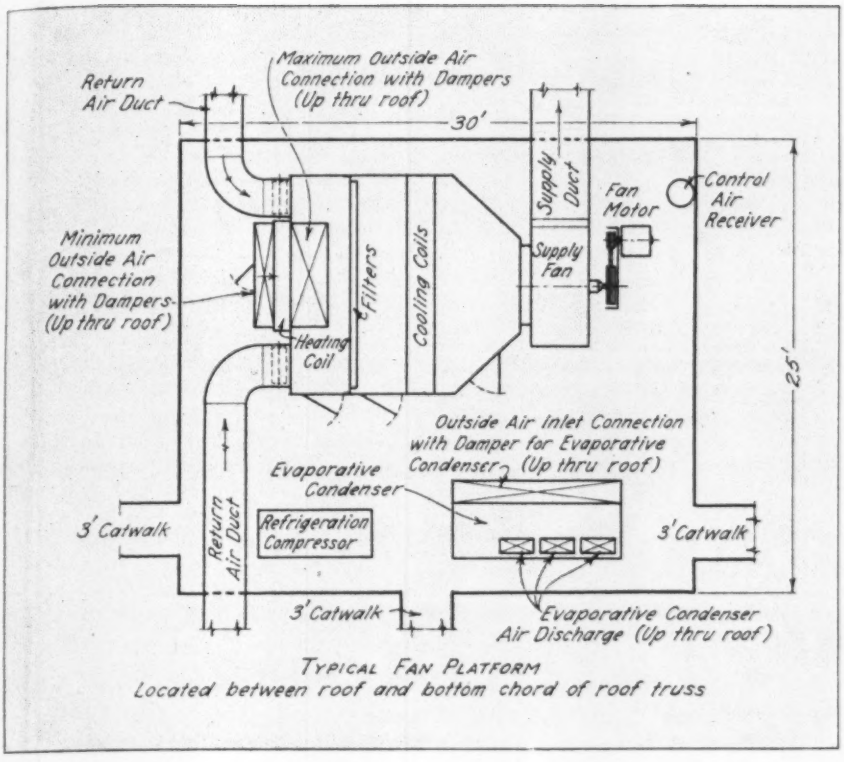
The unitary idea for ventilating, heating, and cooling services was continued in the office and cafeteria buildings. As they, too, are entirely windowless, ventilation is essential and heating and cooling are almost as important. Fluorescent lighting is used throughout the office and cafeteria buildings, and the heavy lighting load makes refrigeration necessary for maintaining comfort conditions in summer. The proper lighting conditions in these buildings is obtained by providing approximately 3 watts per square foot of fluorescent lighting. The inside summer design conditions are 78 F dry bulb and 50 per cent relative humidity, with outside conditions of 90 F dry bulb and 70 F wet bulb. The winter design conditions are 75 F dry bulb inside and 40 F dry bulb outside.

The office buildings are all two fan systems, with a supply and exhaust fan for each system. Due to the great number of zones, and the difficulty in controlling each according to its particular load requirements, a hot and cold plenum design is employed. The

there is very little expensive piping

ever. Among these advantages are

in some cases, the actual power co ts



TYPICAL FAN PLATFORM
Located between roof and bottom chord of roof truss

There are 168 unitary ventilation systems and 125 refrigeration systems

cooling and heating coils are in parallel on the discharge side of the supply fan. Each zone is provided with pneumatic mixing dampers at the hot and cold plenums, with each set of mixing dampers controlled by the zone thermostat. The refrigerating machines and steam heating coils are controlled from the cold and hot plenum thermostats respectively.

Each refrigeration compressor is provided with three steps of capacity; and on the largest office building two refrigerating machines are used, one for approximately one-third and the other for two-thirds of the total system capacity. In addition, these compressors are provided with capacity reduction devices. Each system is complete with its own boiler, refrigeration machines, evaporative condensers, cooling and heating coils, filters, supply and return fans, and control system.

Overhead Air Distribution

An overhead air distribution system, with high velocity, ceiling outlets, is used in all of the office buildings, as well as in the cafeteria building. Supply ducts are largely run exposed at the ceiling, and constructed to simulate beams. In some cases, supply and return ducts are run in attic spaces in which case they are insulated with 2 in. of rock wool. The exposed ducts are not insulated, since they are in the conditioned space and the ceilings of all top floors of these buildings are insulated from the attic spaces. Return ducts are provided from each zone, with return grilles at the floor.

The cafeteria system, serving but one large zone, is a single fan system. Hot and cold plenums are not used, but the heating and cooling coils are in series on the suction side of the supply fan, with the cooling coils controlled in three capacity steps and the heating coils in two steps. The refrigeration compressor also is provided with three capacity steps, and the controls are arranged so that cooling and heating cannot be operating at the same time.

The personnel and welfare building has two independent systems, but only one boiler plant. One system is for the medical section and uses 100 per cent outside air at all times. Both fan systems employ the hot and cold plenums, and each has a supply and a return fan. The return fan for the medical section does not recirculate, however, but serves merely as an exhaust fan. The zone temperatures are controlled by pneumatic mixing dampers at the hot and cold plenums.

All of the office buildings and the cafeteria have thermostats in the outside air ducts for each system, which are set to use maximum outside air between 60 and 80 F dry bulb outside temperatures, as on the larger factory buildings. Under heating conditions below 60 F dry bulb, the outside air dampers close to minimum and the return dampers open full. Under cooling conditions above 80 F dry bulb, the outside air dampers also close and the return dampers open for maximum economy of operation. Also provided in the outside air duct for each system is a master thermostat which automatically resets the inside zone thermostats in accordance with the outside temperature.

A total of 168 unitary ventilation and 125 unitary refrigeration systems is employed. The total supply air circulation is 5,518,670 cfm. The average air change is 14.7 min. Approximately 4,000,000 lb of sheet metal was used for the duct system. There are 41 boilers used with a total equivalent direct radiation of 475,020 sq ft.

The heating, ventilating, and air conditioning overall cost averaged 41 cents per cfm with 81 per cent of the space refrigerated as well as heated and ventilated. Total refrigeration tonnage is 7693.

The connected horsepower figures for heating, ventilating, and air conditioning for the various buildings are quite interesting. The total connected horsepower is 10,696.3. Of this total, the connected horsepower to drive the refrigeration machines is 7061. When the refrigeration auxiliaries (evaporative condenser fan, pumps, etc.) are included, the total connected load for refrigeration is 7,782.1. The balance of the connected horsepower is for the circulating fans and the boiler auxiliaries. The actual brake horsepower on the fans is approximately 85 per cent of the connected horsepower. The actual brake horsepower on the refrigeration compressors at maximum load conditions is approximately 95 per cent of the connected horsepower.

Decentralization vs. Centralization

This plant is the only large aircraft manufacturing plant operating in the United States today in which the unitary plan of refrigeration has been used. Practically all of the aircraft plants of comparative size in the east and middle west employ a central station type of refrigeration system. These jobs have one central water cooling system, with chilled water being pumped to the cooling coils at the various fan stations. It is my opinion that such water cooling systems run on the average 15 to 20 per cent more in first cost than a comparable direct expansion unitary refrigeration system, providing each has the same number of fan stations. The extra equipment building, water pumps, piping, insulation, and pipe trenches between buildings make the cost of the central station job run considerably above the unitary direct expansion system.

In order to cut piping costs, most of these central station jobs use hot water for heating and employ the same piping and blast coils for both heating and cooling. Such a design is satisfactory for some climates, but not in Southern California, where the change from heating to cooling must be very rapid, as heating is often required in the morning and cooling in the afternoon. With the unitary system, it is possible to have heating in some zones and cooling in others in the same building at the same time.

Another advantage of the unitary system is the high resale value of the machinery should it become necessary to dismantle the plant after the war.

There is very little expensive piping to junk. The salvaged cooling equipment would be just the right capacity for commercial use for air conditioning in the neighborhood theater, small department store, or small hotel.

I believe that the central station plant becomes comparable in first cost with the unitary system only when the number of fan stations in the former is greatly reduced as compared with the latter. On the Douglas job, such procedure would have made the ducts so large that they could not be conveniently run between the truss members, thus necessitating higher trusses or the running of ducts exposed on the roof. Furthermore, the unitary idea of ventilation, so vital in a blackout factory in case of actual bombing, would be largely destroyed.

The central water cooling system does have a few advantages, however. Among these advantages are ease of control with water, and probable cheaper maintenance cost because of the smaller operating crew. However, when consideration is taken of the extra water pumping cost with a central station job and the low hp per ton possible with direct expansion, as against a higher hp per ton when cooling water to about 40 F as required with the central station system, it is doubtful to me if there is any saving in operating costs. The auxiliaries for the central station job would have to include water circulating pumps, as well as cooling towers or evaporative condensers with fans and pumps, and so would be greater than for the unitary system. Thus, the unitary system is more economical in power used than the central water cooling layout, in my opinion. However, central station jobs are adaptable to steam turbine drive, so in some cases, the actual power costs where steam generation is cheap may not be any more than on the decentralized job using electricity.

California usually runs to superlatives, and the Douglas Aircraft plant at Long Beach is no exception. It is one of the largest single aircraft manufacturing plants in the United States, and is one of the largest completely air conditioned factories. Two of the large windowless office buildings of the world are the administration building and the engineering building. All in all, this plant is just about the largest decentralized air conditioning project in the history of the industry. This project was designed by Edward Cray Taylor and Ellis Wing Taylor, architects. The heating, ventilating, and air conditioning design was under the direction of Oran W. Ott, consulting mechanical engineer.

WPB GIVES ANSWERS ON L-38 ORDER

THE following questions and answers on the War Production Board's limitation order L-38 (industrial and commercial refrigerating and air conditioning machinery and equipment) as amended May 28, 1943, was issued last month by the general industrial equipment division of the WPB:

Does the term "system" include the following: (a) All types of evaporative coolers. (b) Water coolers of the cooperage type. (c) Cooling towers of the atmospheric, forced draft, and washer type?

Answer: The word "system" is used to cover both refrigerating and air conditioning systems.

a) It includes such equipment as evaporative coolers designed for air conditioning purposes. There are a number of types of apparatus used merely for the transfer of heat from one substance to another, however, which are not included by the definition. These usually consist of pipe, tubing, or other apparatus used as a conduit for the passage of the substance to be cooled, in the course of which heat is exchanged or transferred from such substance, directly into the atmosphere or into water which is not artificially cooled, and without the use of any other cooling or refrigerating equipment or machinery. Among the types of apparatus sometimes used in this manner, and which are not within the definition of "system" when so used, are the following: Oil quenching equipment, shell and tube coolers, transformer oil coolers, generator cooling coils, and radio tube coolers. The pipe or tubing previously referred to may be subjected to a water spray or exposed to water not artificially cooled, which aids in the dissipation of the heat, but this does not bring the apparatus within the definition. For example, some of these types of apparatus used on boats are designed to pass ocean or river water through the coolers for such purposes as cooling engine oil, and such apparatus is not within the definition.

b) Containers of the so-called "cooperage type" such as "railroad water kegs," "harvest kegs," and "water breakers" for use in life boats and life rafts, which are not used or designed for use with coils or other apparatus intended for the application of ice or refrigerants in lowering the temperature, are not within the definition of the order.

c) Equipment such as cooling towers of the atmospheric, forced draft or washer type is included under order L-38 only when such equipment is a part of a "system" as defined in paragraph (a) (1) of the order.

How must the ratings be obtained for deliveries for maintenance and repair service?

Answer: Prior to the amendment of L-38 on May 20, 1943, repair parts could be delivered to the owner (consumer) of a system only for "emergency repair service" as then defined in the order (in addition to the deliveries of repair parts permitted under "authorized orders," or for direct use by the Army and other agencies designated in (b) (1) (i) (*d*). Parts may now be delivered for "maintenance and repair service" as now defined, provided deliveries are made under an order rated AA-5 or higher. It is immaterial whether the rating is assigned under order P-126, under CMP 5, on a PD-1A certificate, or in any other way. Regardless of how the rating is obtained, however, deliveries can be made only in accordance with L-38. It is to be particularly noted that equipment which would constitute a capital addition cannot be delivered for "maintenance and repair service" even though CMP 5 permits the use of the ratings assigned by it for capital additions of a limited amount. Even though ratings for such capital additions may be assigned under CMP 5 or otherwise, it is still necessary to secure an "authorized order" for their delivery to be permissible under order L-38.

Do manufacturers require AA-5 or better rating to repair a compressor or unit in their own service department taking into consideration that some new parts would naturally be required?

Answer: No. The amended order L-38 permits the exchange of a used subassembly of a type which is normally exchanged in assembled form in order to permit immediate restoration of the installed system to service and subsequent shop reconditioning of such subassembly. Therefore, if such a subassembly was returned to the manufacturer, he would not require a rating in order to repair it. However, such a repaired subassembly cannot be delivered to a person acquiring the same for use except under an order rated AA-5 or higher.

Should the War Production Board be communicated with in regard to applications for refrigerating and air conditioning equipment filed on forms PD-830 and PD-831?

Answer: Yes, but allow enough time for the original application to reach the general industrial equipment division and an additional 10 days for the application to be processed.

Heating of the Future

E. N. McDonnell Consults the Crystal Ball to Spot Trends in Postwar Heating Styles

I SUSPECT that when the typical business man allows his mind to roam along the avenue of postwar planning, he finds himself torn between conflicting emotions. On one side is the time honored superstition that it's bad business to count unhatched chickens or celebrate unwon victories. On the other is the thought that refusal to plan is a confession of weak faith in our ability to win the war. So plan we must, meantime making sure that our main and immediate efforts are concentrated on the victorious objective — without which our plans would be simply "the stuff that dreams are made of."

There are a few safe guesses that can be made right at the start as to the future trend of space heating. I don't think there is any question, for instance, that even the most modest home will have automatic heat. I also expect homes—clear down to the simplest—to be given ever-better insulation, permitting ever-smaller heating plants.

We've Only Scratched the Surface

As to air conditioning, I think we have merely scratched the surface of this great and coming field. I think the condition of air in living quarters, and its effect on the health of the occupants, will be a major study and a major business. People have already had a taste, here and there, of something better in heating. They know that it *is* possible to have clean, wholesome air; proper humidity the whole year through; smooth, even, pervading heat every waking hour; cooling and dehumidifying in the hot days of summer.

We of the heating industry will have to give the postwar world the even, automatically controlled heating and the proper air conditioning that people are learning to demand. What form will it take?

Plan Now

Our main and immediate efforts must be concentrated on winning the war; we must also plan for the future. Mr. McDonnell—president of McDonnell & Miller—speculates here on general developments in heating practice, gives his opinions of probable trends

"Wet Heat" and "Dry Heat"

You can be sure that there will continue to be a clash between "wet heat" and "dry heat"—to use the quick designations some of us apply to the warm air and to the hot water and steam camps. Each will claim that it has the royal road to ideal heating and air conditioning. My own opinions, I will admit, may be slightly warped.

Yes, I am still loyal to hot water and steam heat. But despite this, I think we should look all the facts in the face, fairly and honestly. I think each of us should be ready to see the shortcomings of his own as well as the other fellow's kind of heat. Only by seeing the faults can we correct them. There is no use fooling ourselves, and there is no use being fooled by others, either.

As a matter of fact, there must be merit to both forms of heat or one would have crowded the other out of the picture long ago. Properly developed, either is probably capable of far better results than it has achieved up to this time. Since both have their merits, the ultimate achievement of either will depend, first, on how much smart engineering goes into their development; and second, on how skillfully their accomplishments are publicly explained.

More Radiation at Lower Temperature

I think there is plenty of future for "wet" heat if we develop it properly, and then tell and show the public what we have. What form the development will take is difficult to predict, but I expect to see well-controlled, forced hot water become a predominant type of heating in smaller dwellings, with *more* radiation and lower temperature, if you please, rather than following the present trend of less radiation and higher temperatures in the radiators.

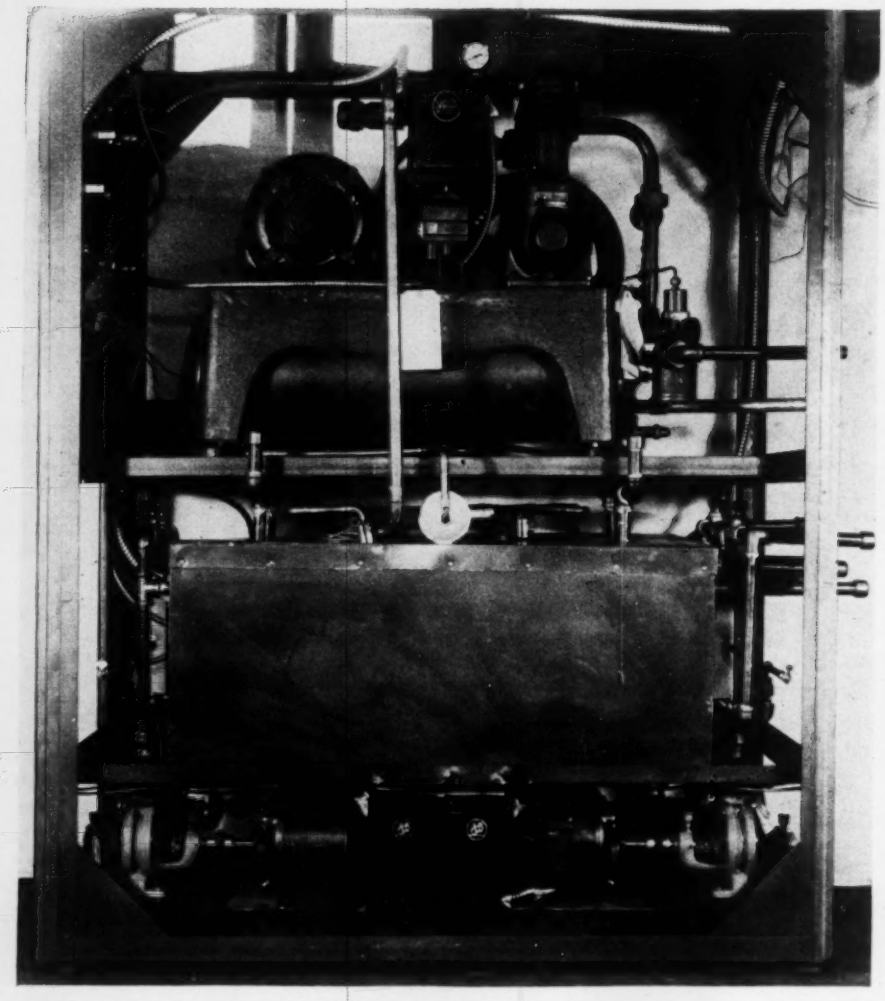
I realize that this sounds like heresy—that it smacks of bringing back the big radiator with all the sales resistance the term "radiator" calls to mind. But why have the old style radiator at all? And why not give whatever we substitute for it a new name that gets clear away from the term "radiator"?

Just what form the heating elements will take I can only guess. Maybe they will be on the order of panel heating, but more in package form. Of course some miracle idea may stride forth, too, but most miracles just go along looking for some place to happen.

I expect to see a *continuous* type of heating and better control with less overshooting, hunting, and hot and cold spots. This, whether it is "wet" or "dry" heat. I expect to see the manufacturers of primary heating develop a more complete and engineered package for the contractor. This is almost a must.

Standardized Performance Ratings

Above all, I should like to see *all* heating equipment — and I mean ALL—tested and rated by a national organization, set up by the industry to standardize performance ratings.



A refrigeration unit for resistance welding, with four coolant pumps and four piping circuits

Proper Piping Is Important When Cooling Welding Electrodes

A. L. MUNSON TELLS WHY AND HOW OF REFRIGERATED RESISTANCE WELDING

REFRIGERATION has become an essential tool in the fabrication of the implements and materials of war. Innumerable new uses have been found for refrigeration during the last few years, particularly in industry. Welding is one example.

When applying refrigeration to a resistance welding machine, the coolant (water, brine, or antifreeze) must be piped from the refrigeration unit to the welder electrodes. Since there is a large pressure drop through the electrodes and electrode holders, special care must be observed in laying out the piping so that a minimum pressure drop is added by the coolant circuits between the refrigeration unit and the welder.

When we think of welding, we think of heat—glowing red or dazzling white—which causes metals to fuse together in a strong bond. The spectacle of two pieces of metal bristling with white frost coming together and making a weld appeals to the imagination because it is so contrary to preconceived notions. The two are so diametrically opposed—heat and cold. But it is this combination that has made aluminum spot welding entirely practical and faster than riveting.

Spot welding is a metal fabricating process in which the fusing temperature is generated at the joint by the inherent resistance of the joint to the flow of an electric current.

In a resistance welding operation, the basic formula is expressed as "Heat equals I^2RT," in which I is the secondary (or welding) current, R is the electrical resistance of the parts being welded, and T is time. Three of the factors affecting this formula are current, time, and pressure; and a resistance welding machine must have means for controlling them.

Current requirements for welding aluminum are three or more times the values used in welding steel of similar gage. A spot welder designed to weld two pieces of 1/16 in. thick steel will not be heavy enough to weld the same thickness in aluminum.

Pressure required to bring the upper and lower electrodes together over the joint with sufficient force to do the welding can be applied by air or hydraulic cylinders. The amount of pressure must be adjusted, since different types and sizes of materials require different pressures between the electrodes and the work.

Timing control is essential in resistance welding. Electronic controls provide timing in "cycles" instead of seconds. Since there are 60 cycles in each second in a normal power supply, this means timing is possible to 1/60th of a second and even less.

Refrigerated Welding

When we think of welding, we think of heat; thus, the spectacle of two pieces of metal bristling with white frost coming together and making a weld appeals to the imagination because it is so contrary to preconceived notions. Refrigerated resistance welding of aluminum appeals to the imagination also because it is contributing so greatly to our war effort.

Mr. Munson, manager of Frostrode Products, explains here the how and why of refrigerated welding. Much of his comment is devoted to the necessary piping—for, as in almost every industrial process, piping plays an important role in this production technique.

In order to make a weld, a welding machine must be arranged to perform certain functions in a certain sequence determined by the settings in the control panel. Current cannot be permitted to pass through the electrodes until they have been brought together on the work under the proper pressure. Therefore, the machine sequence would normally be:

1) Squeeze Time—The process of bringing points together and holding them together under pressures for a definite time.

2) Weld Time (Often broken up into a series of pulsations of heat time, cool time, etc., as for steel to prevent overheating and melting of the material)—The duration time in which the welding current is applied. In aluminum welding this time is a fraction of one second since a very high current is used and must be of very short duration, due to the nature of the material.

3) Hold Time—The time for which the points must remain closed after current flow has stopped to give the metal a chance to fuse and cool. This is sometimes called "forging pressure."

4) Off Time—When automatic operation is desired there must be an off time to allow moving the work to a new spot location in readiness for another weld.

With synchronous timing controls, each timing cycle is begun at that point on the sine curve where it is zero in current value. This eliminates sudden line surges which are very objectionable and which cause fuses to blow and power companies to object.

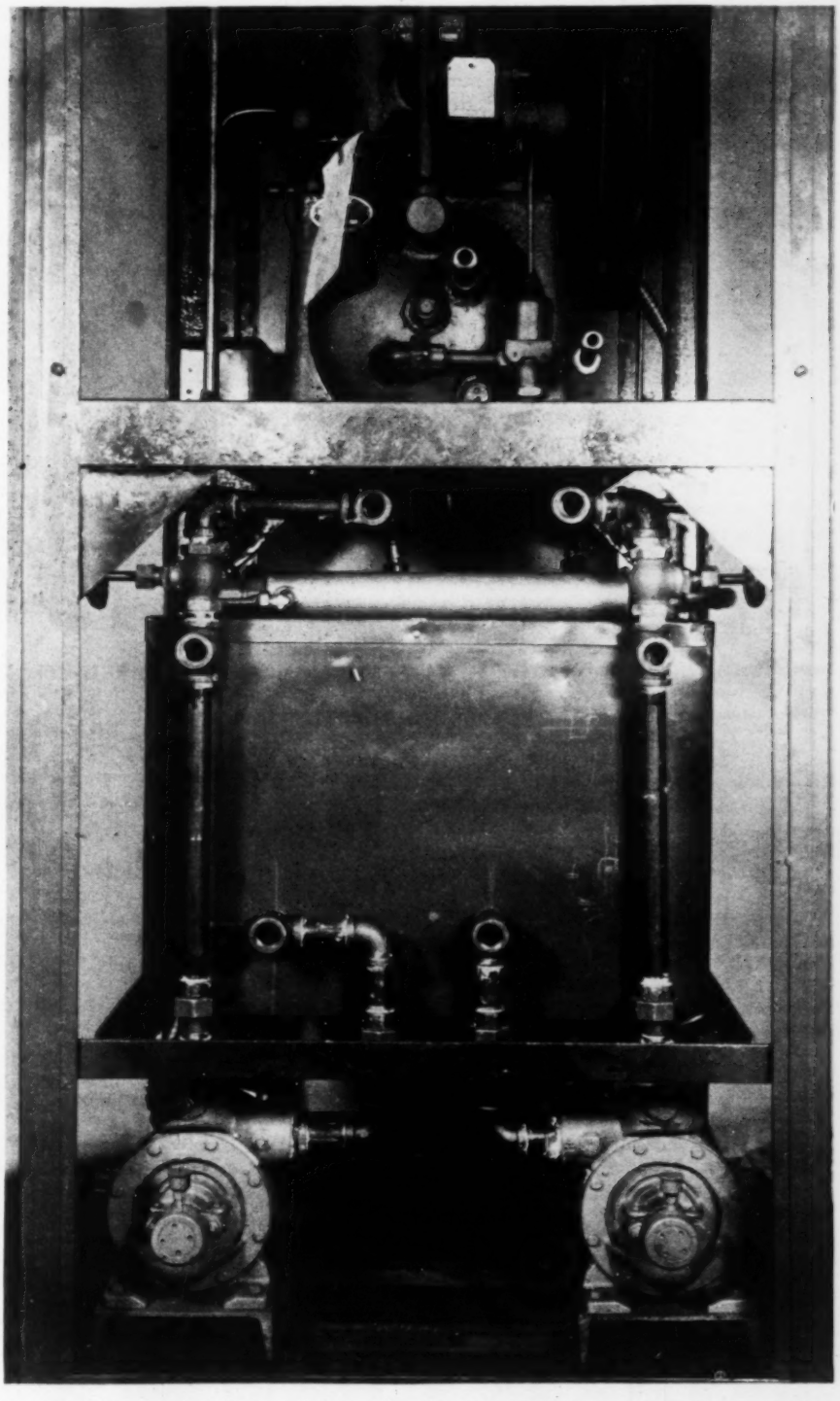
Surface Preparation Important

Before a weld can be made, the work must be cleaned and otherwise prepared. The purpose of surface preparation is to eliminate wide variations in the heat of welding caused by variations in the contact surface resistance due to foreign matter on the surface—and also to reduce the heating between work and electrodes.

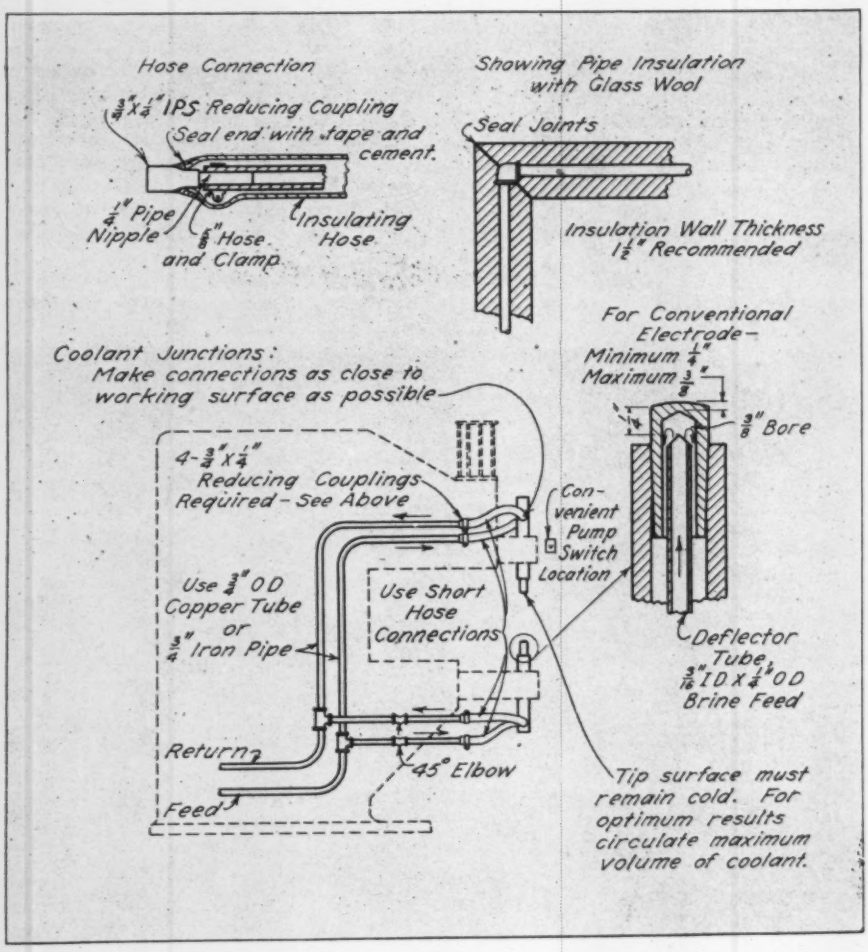
Work can often be ruined by improper treatment or cleaning, and in aluminum work, premature "pick up" of aluminum by the electrode face will result if the surface is contaminated. Since aluminum has the unhappy faculty of picking up soon enough even with proper cleaning, this cleaning is important and is given a great deal of serious attention by welding engineers.

The surface resistance of aluminum sheets is increased by the pressure on the sheet of foreign substances deposited either by handling or by some chemical action of atmosphere, etc. Fumes, smoke, moisture, etc., in the atmosphere will have definite effects on the oxide coating. Dirt, grit, and dust will also cause some trouble and can often limit the number of spots obtainable between electrode dressings.

Aluminum alloys readily alloy with copper, especially at high tempera-



Restricted space and the need for as few bends and fittings as possible make it a real problem to achieve a sensible and economical piping layout in these cabinets


Hose Connection
3/4"x1/4" IPS Reducing Coupling
Seal end with tape and cement.
1/4" Pipe Nipple
5/8" Hose and Clamp
Insulating Hose
Showing Pipe Insulation with Glass Wool
Seal Joints
Insulation Wall Thickness 1 1/2" Recommended
For Conventional Electrode—
Minimum 1/4"
Maximum 3/8"
3/8" Bore
Coolant Junctions: Make connections as close to working surface as possible
4-3/4"x1/4" Reducing Couplings Required - See Above
Convenient Pump Switch Location
Use 3/4" OD Copper Tube or 3/4" Iron Pipe
Use Short Hose Connections
Deflector Tube 3/16" ID x 1/4" OD Brine Feed
Return
45° Elbow
Feed
Tip surface must remain cold. For optimum results circulate maximum volume of coolant.

Sketches illustrating various piping details for refrigerated welding

tures. It is, therefore, important that the temperature of the copper electrode face, which is in contact with the aluminum, be kept as low as possible, to avoid pick up of the aluminum being welded. This is the basic reason for the use of refrigeration. We try to hold this face temperature below the fusion or alloying point in order to retard alloying, or pick up. If we could consistently do that we might be able to weld forever on one set of electrodes.

Refrigeration also assists materially in retarding the so-called "mushrooming" of electrodes. Heat and pressure and the constant pounding together cause distortion in the shape of the electrode at the face. This, too, is a serious cause of short electrode face life.

This brief summary of welding practice will indicate what we are up against when we try to apply refrigeration to a welding machine. It is essential to know welding before attempting to apply refrigeration to this complicated welding procedure.

There is no easy way to determine refrigerating loads. Each size or thickness of sheet requires different heat. The condition of the sheet will cause variations. The type of oxide coating will cause variations. Each alloy will be different.

The condition and type of electrodes will cause variations. The throat depth and height must be considered. Any ferrous metal in the throat field will make a difference. The method of cleaning and consistency of cleaning are important, as are atmospheric conditions and the polarity of electrodes.

Cooling surface available in the electrode is of utmost importance, but only recently has much attention been paid to this factor. Coolant flow and volume of coolant are also very important. All these factors and more must be considered when refrigeration is to be applied to welding.

Coolant Temperature

We have found the best coolant temperature to be between 0 F and 10 F. A minimum of 2 gpm should be circulated through each electrode. However, there is some evidence indicating that for light gages of aluminum (0.020 in.) a temperature of 15 or 20 F works well. But in by far the greatest number of cases, 0 to 10 F has given better results.

For steel work, we often use 40 F, such as in gun type welders. But even for steel we have found 0 F desirable in many cases. With one welder, for example, which permits accurate heat treating after welding through use of a thermocouple inside one of the electrodes, armorplate can be very successfully welded and heat treated after welding at this 0 F temperature.

In this operation, a series of pulsating electrical currents of varying intensity are used so that any predetermined degree of heat can be accurately obtained. Consequently, it is simple to obtain approximately the same hardness and toughness in the weld as in the original metal. Refrigerated electrodes assist in the quick quenching and also retard point mushrooming.

How Coolant Is Piped

At present, we use electrodes cooled with a mixture of antifreeze, such as alcohol and water, fed to the tip through rubber hose and a ¾ in. iron pipe. When we entered the field, we found that tip thicknesses ranging up to ¾ in. of metal between the coolant and face of the tip were in common usage. Naturally, this provided an overwhelming wall for the refrigeration to work against. Changes in electrodes since then have reduced that wall thickness to the thinnest dimension which will maintain the weight of the electrode under pressures encountered on the job.

Electrode tips are commonly dressed with a file and/or oxalite paper of fine texture abrasive. This cleaning is one of the worst headaches, since it requires valuable production time. It usually takes from 5 to as much as 20 min to clean one set of points.

Refrigeration increases the current carrying capacity of the electrode at low temperatures. It is important that equal amounts of refrigeration be supplied to each electrode for uniform results. Here is where the piping layout is important. As few fittings and as few pipe bends as possible should be used. Short, simple connections are best. However, sometimes a central system is used, or a series of small multiple systems is employed. The piping layout must be carefully considered on these multiple systems because it is essential that each electrode on each welder receive equal and adequate coolant flow.

It is impossible to say offhand what size refrigeration unit will be required for a given job. One manufacturer makes a line of units ranging from ¼ hp up to and including 10 hp, but loads can only be determined from experience and welding knowledge. There is no easy formula. Piping is used for many different duties in these welding applications. There is ¼ and ½ in. air piping for supplying compressed air to the welder head. There is ½ and ¾ in. piping for water lines, high pressure oil lines, and coolant circuits. There are also the electrical piping conduits, which are often 2 and 3 in. The numerous gages recording oil pressures, air pressures, water pressures, coolant

pressures, and "Freon" pressures must have their individual pipe connections. There are several long pipe nipples welded into the coolant tank and filled with a light oil to serve as thermostat and thermometer wells.

Most of the "Freon" piping and all of the coolant piping is normally insulated with 1½ in. of good insulation.

The accompanying illustrations show some piping arrangements and connections. Because these units must be compact, all the equipment must be crowded into a small space, and because only as few bends and restricting fittings as possible can be used, it is often a real problem to achieve a sensible and economical piping arrangement within the cabinet. You will note that although these cabinets are almost completely filled by the compressor and brine tank and pumps, a neat and simple piping arrangement has been obtained. The pictures were taken before insulation was applied so that the piping arrangements could be seen.

WHY A LOWER NIGHT TEMPERATURE SAVES FUEL

THE EDITOR—

Applications for supplementary fuel oil rations have indicated that opinion still is divided as to whether or not fuel can be saved by lowering temperatures at night. The surprising feature is that so many think that it is a matter of opinion rather than of fundamental law.

The following comparison has enabled some laymen to understand the principle. Previous recommendations for saving fuel by lowering night temperatures apparently have not convinced everyone to do so, because the principle involved has not been explained. Many understand saving by insulation, and by lowering temperatures for long intervals but not by lowering temperatures over night or for any period of short duration.

Prior to the war, lack of general knowledge of heating principles was of little consequence, but it is of vital importance now. It is possible that as much as 3 or 4 per cent of the oil now used for space heating might be saved by making available to everyone a simple explanation of one fundamental principle.

The fundamental natural law of heat transfer applied to space heating is that the rate of heat loss is exactly proportional to the difference in temperature between inside and outside. Therefore, for given conditions any reduction in average inside temperature will result in a saving exactly proportional to the reduction in temperature difference.

The saving obtained by lowering temperatures at night may be partially offset in infrequent cases in which the fuel oil burner and furnace or boiler are not coordinated. In such cases, oil is burned at a much greater rate than the furnace or boiler can absorb heat from the burning fuel and transfer it to the occupied space. The excess heat which cannot be absorbed during the long period of burner operation in raising to daytime temperature is lost up the chimney.

Compare a tank 75 in. in height having a narrow slit from top to bottom with water flowing in at the top at the same rate it flows out the slit to a building being maintained at a temperature of 75 F when it is 0 F outside.

Assume the supply of water to be shut off until the level in the tank drops to 60 in. and then turned on until the level again reaches 75 in. During this interval, less water is used than would have been if the level had been maintained at 75 in., the amount being directly proportional to the difference in average water levels. Obviously, water at any level below 75 in. will not run out as fast as it will at 75 in. Flow of heat is similar.

In regaining the 75 in. level, however, if water were admitted in such a way as to splash over the sides of the tank, some of the saving in water would be lost. This is similar to heating plants in which fuel is burned faster than the heating equipment can absorb it.—R. A. PARSONS.

STOKER MAKERS TO ESTABLISH FIREBOX DIMENSIONS; ADOPT STATEMENT ON DUST TREATMENT OF COAL

Prominent among the problems and subjects given consideration at the mechanical underfeed coal stoker industry's second annual war conference and the 24th annual meeting of the Stoker Manufacturers' Association held at Lake Wawasee, Ind., last month was the proposed organization of a new heating industry promotional effort named the Indoor Climate Institute. Following a presentation of this institute's aims and purposes by J. M. McClintock, SMA president, who represents the stoker industry on the institute's organization committee, the association's membership unanimously endorsed the project.

The association also approved recommendations of the engineering and research committee to establish minimum firebox dimensions for stoker fired boilers and furnaces from the small domestic sizes to commercial and industrial boilers having a capacity of 1200 lb per hr of coal, stoker fired; to establish a uniform method of rating and testing stokers; and to affix SMA plates to all stokers of member companies meeting test requirements certifying the feeding rate of various size stokers. A statement prepared by the association's engineering and research committee concerning the dustless treatment of stoker coals with hygroscopic salt base solutions was approved as follows:

"The two most common materials which have been used for dust allaying treatment of stoker coals are: (1) Solutions of hygroscopic salts (primarily calcium chloride); (2) Oils and waxes.

"Under the War Production Board limitation order L-56, as amended in May, 1942, the use of oils and waxes was prohibited for the purpose of dust allaying of coal. This federal regulation leaves only the salt base materials commercially available for this purpose.

"The increased use of salt base materials brought about by the prohibition of the use of oils and waxes has prompted many inquiries to the Stoker Manufacturers Association and its individual members as to the possible harmful effects of such treatment on automatic coal stoker equipment.

"The members of the Stoker Manufacturers Association, through their engineering and research committee, have carefully reviewed the results of the two above methods for treating stoker coal. Solutions of hygroscopic salts are effective in allaying dust only when the coal is stored in a damp atmosphere.

"The following is a brief statement of the stoker industry's experience:

"*Over a period of years and on many thousands of stoker installations it has been found that the deterioration of metal parts by corrosion has been greatly accelerated and that the maintenance cost has been higher on stokers which have used coals treated with hygroscopic salts (primarily calcium chloride, with or without inhibitors).*

"Where circumstances dictate the use of such treatment, it should be with a recognition of the fact that the maintenance cost may be increased and the life of the equipment shortened."

Water Sprayed Direct Expansion Coils

Their Theory and Characteristics

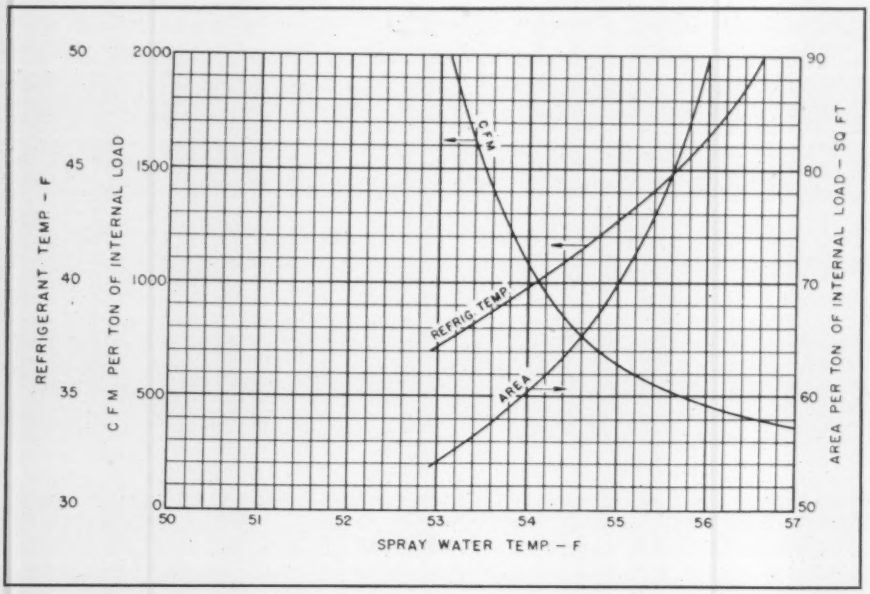


Fig. 11—Characteristic curves for an installation in which *volume* of outdoor air is constant

ALTHOUGH USED EXTENSIVELY IN THE MANUFACTURE AND TESTING OF WAR GOODS, THE FUNDAMENTALS OF SUCH COILS HAVE NEVER BEFORE BEEN ANALYZED AS COMPLETELY AS IN THIS TREATMENT BY WILLIAM GOODMAN

THE theory and characteristics of water sprayed direct expansion coils have been discussed in detail in the April, May, and June issues of HPAC. We conclude our treatment of the subject this month with the following information on selecting coils for a constant quantity of outdoor air, selecting a coil for all recirculated air, and selecting a coil for a given refrigerant temperature.

Selecting Coil for a Constant Quantity of Outdoor Air

The cycle in which a constant quantity of outdoor air is supplied is illustrated diagrammatically on the psychrometric chart of Fig. 9, which appeared on p. 296 of the June issue. This figure has been discussed in preceding sections. To select a coil, first assume some location for point *2* on line *3-5*. Next, figure the weight of air required by means of equation 9, p. 295, June issue. After the weight to be circulated has been determined, the percentage of outdoor air in the mixture can be figured from the given quantity of outdoor air. Point *1* can then readily be located. If the specified quantity of outdoor air amounts to, say, 20 per cent of the total quantity of air to be circulated, distance *1-3* will be 20 per cent of distance *3-4*. After line *1-2* of Fig. 9 has been drawn and extended to point *6*, a whole series of parallel lines can be drawn which will determine points *1* and *6* for various values of point *2* along line *3-5* of Fig. 9. Once a series of parallel lines has been drawn — from which corresponding values of h_1, h_2, and h_w can be determined—the method of selecting and computing the coils is identical with the methods illustrated by example 5, on pp. 298-299, June issue.

The variations in cfm and area per ton of internal load and the variation in refrigerant temperature for various assumed spray water temperatures are shown in Fig. 11. This figure was plotted for the conditions of example 5 except that the quantity of outdoor air was assumed to be constant at a value of 1350 lb per hr per ton of internal load. Notice in Fig. 11 that, unlike the case in which the *percentage* of outdoor air is constant, the required area continually increases as the spray water temperature is increased. Notice also that the cfm per ton changes rapidly especially at the lower spray water temperatures. The cfm per ton approaches infinity as the lowest possible spray water temperature of 52.1 F is approached. As described in a preceding section, this lowest possible spray water temperature is obtained by drawing through point *2* of Fig. 9 a condition line parallel to condition line *1-6*. The lowest possible spray water temperature is read at point *8* where the dotted line through point *3* intersects the saturation curve.

As the quantity of air increases, the area required decreases. Hence in selecting a coil, it is necessary to make a compromise between a reasonable quantity of air and a reasonable area. What is reasonable will of course depend upon the conditions surrounding the particular installation for which the coil and air volume are to be selected. Occasionally the necessity of avoiding too low a refrigerant temperature may dictate the choice of area and air quantity.

Note in Figs. 10 [p. 298, June issue] and 11 that for the same spray water temperature the refrigerant temperature is also the same. In other words, for both a constant percentage of outdoor air and a constant quantity of outdoor air, the refrigerant temperatures are the same for the same spray water temperature. If this is true, then according to equation 3 [p. 167, April issue] the ratio Q/A must also be the same for both cases.

Selecting Coil for All Recirculated Air

Fig. 9 [p. 296, June issue] will also be used to illustrate the case in which no outdoor air is used, only air withdrawn from the conditioned room being circulated. For the purpose of this discussion, ignore points *1* and *2* of Fig. 9.

When all return air is used, the air in the condition represented by point *3* is withdrawn from the room and enters the sprayed coil in the same condition. The air must be cooled to some point like *2* along line *3-5*. In this case, line *3-5* represents both the moisture ratio line for the room and the condition line along which the cooling of the air must take place. When only recirculated air is used, the moisture ratio line and the condition line coincide. Inasmuch as both the moisture ratio line and the condition line coincide, it is obvious that regardless of where point *2* is located along line *3-5* the spray water temperature must be constant and represented by point *5* of Fig. 9.

After locating point *5*, from which the spray water temperature is determined, the ratio A/G can be computed for various assumed locations of point *2*. The most convenient way

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of figuring the ratio A/G for various locations of point *2* is by means of the following formula [derived on p. 327 of the May, 1938, HPAC]:

$$\log_e \frac{h_3 - h_w}{h_2 - h_w} = M \ldots\ldots [12]$$

In equation 12, natural logarithms must be used. To use logarithms to the base 10, the following form of equation 12 is used.

$$2.3 \log_{10} \frac{h_3 - h_w}{h_2 - h_w} = M \ldots\ldots [12a]$$

Inasmuch as h_3 and h_w are known and h_2 is assumed, either equation 12 or 12a can be used to find M. Equation 2 [p. 166, April issue] can then be used to find the ratio A/G. When solving for M for different values of h_2, the value of h_w will of course be constant regardless of the value of h_2.

For any assumed location of point *2*, the value of G can be found by means of equation 9 [p. 295, June issue]. Knowing A/G and G, the value of A can be computed.

The variations in area, cfm, and refrigerant temperature for this case are illustrated in Fig. 12. This figure has been plotted for the conditions of example 5, except of course that no outdoor air was figured. The area required decreases rapidly with an increase in the assumed wet bulb temperature of the air supply. However, as the wet bulb temperature of the air supply is increased, the required air quantity increases. Hence, for this case it is also necessary to compromise between the quantity of air to be circulated and the area of the coil to be installed. Notice also that the required refrigerant temperature falls as the final wet bulb temperature is increased. Lower refrigerant temperatures are required with higher wet bulb temperatures because of the decrease in area.

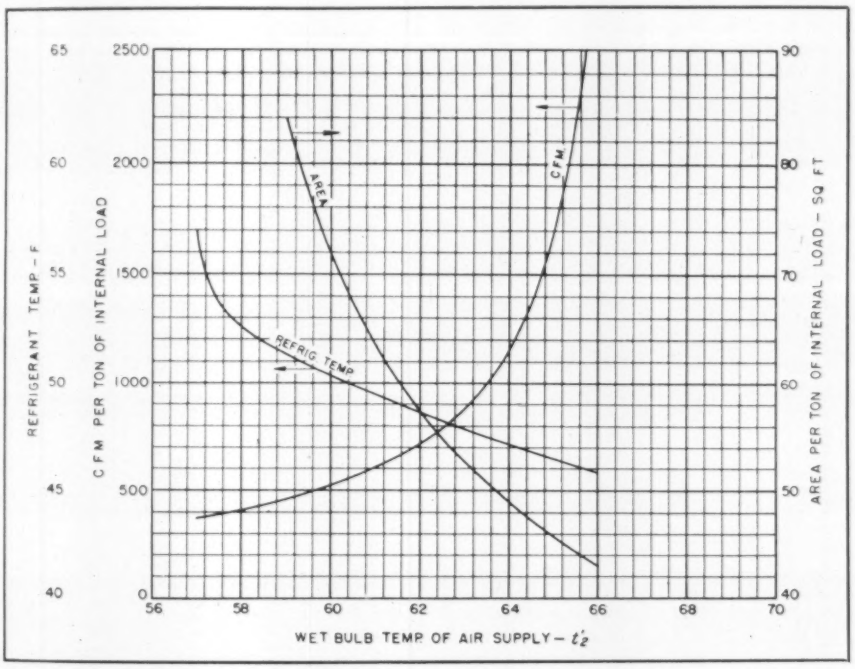


Fig. 12—Characteristic curves for an installation in which 100 per cent recirculated air is used. No outdoor air to be supplied

Selecting Coil for Given Refrigerant Temperature

When the refrigerant temperature is fixed, only one surface area and one air quantity will satisfy the conditions imposed by a given moisture ratio line. Unlike the preceding cases in which the refrigerant temperature was not fixed, no choice of area or cfm is possible when the refrigerant temperature is given.

If curves like those in Figs. 10 and 11 have been prepared, it is possible to read from these curves the required area and cfm for the given refrigerant temperature. Thus, if the required refrigerant temperature were 40 F for the case illustrated in Fig. 10, the spray water temperature would be 54.1 F; the required air quantity would be 910 cfm; and the required surface area 63 sq ft per internal ton. For the case illustrated in Fig. 11, for a refrigerant temperature of 40 F, the spray water temperature would also be 54.1 F; the required air quantity would be 1,020 cfm; and the required surface area 61 sq ft per ton of internal load.

If curves like those in Figs. 10 and 11 have not been prepared, the required cfm, final temperature of the air, and the spray water temperature can be determined directly from the psychrometric chart. The method of determining these quantities for the case in which a constant percentage of outdoor air is to be supplied is illustrated on the skeleton psychro-

Fundamental

Sprayed direct expansion coils are widely used in air conditioning and refrigeration work. Coils sprayed with water are used in air conditioning, and brine sprayed coils are, of course, used in low temperature air conditioning and refrigeration installations.

Because such coils are used extensively today for all kinds of manufacturing and testing in connection with the war effort, a fundamental treatment of their theory and characteristics is especially timely.

In spite of the fact that such coils have been used for many years, such a treatment has never before been published. . . . In the article of which this is the fourth and concluding part, the theory and characteristics of water sprayed coils are covered in a simple and thorough fashion with many illustrative examples to show not only how the characteristics of such coils are computed, but also to show the effect of variations in the various quantities which affect the performance.

A thorough understanding of the basic characteristics and theory of sprayed coils should result in much more efficient and satisfactory installations. . . . Mr. Goodman is consulting engineer, the Trane Co., and a member of HPAC's board of consulting and contributing editors.

Symbols

A = area, sq ft;
G = weight of dry air through coil, lb per hr;
h_1 = initial enthalpy (total heat content) of air entering sprayed coil, Btu per lb of dry air;
h_3 = final enthalpy (total heat content) of air leaving sprayed coil, Btu per lb of dry air;
h_s = enthalpy (total heat content) of room air, Btu per lb of dry air;
h_w = enthalpy (total heat content) of saturated air at a temperature equal to the temperature of the spray water, Btu per lb of dry air;
M = a quantity defined by equation 2 [p. 166, April issue];
N = a quantity defined by equation 6 [p. 167 April issue];
N_L = limiting value of N as defined by equation 8 [p. 246, May issue];
Q = total quantity of heat removed from the air, Btu per hr;
Q_t = total internal heat gain of conditioned space (equals sum of sensible and latent heat gains), Btu per hr;
Z = a quantity that depends on M [see Table 1, p. 166, April issue].

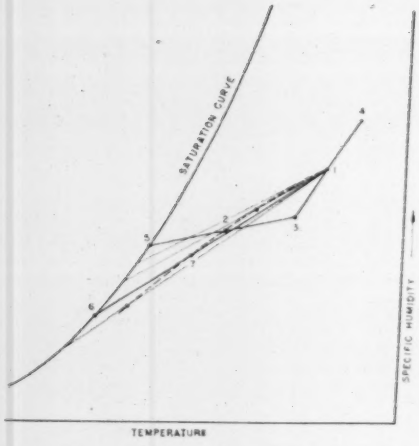


Fig. 13 — Diagrammatic illustration on psychrometric chart of method of determining final wet bulb temperature and cfm for installation in which both *percentage* of outdoor air and refrigerant temperature are given

metric chart of Fig. 13, which is similar to Fig. 8. Because the percentage of outdoor air is to be constant, point *1* may be located immediately on line *3-4*. Corresponding values of cfm and final wet bulb temperature for any given spray water temperature can be read from curves like those in Fig. 7 [p. 244, May issue] or computed by the methods illustrated in example 4 [p. 247, May issue]. Although example 4 shows only how the total load on the coil can be computed, the final wet bulb temperature can be determined from the computed value of the total load by means of equation 10 [p. 299, June issue].

Once several sets of corresponding values of spray water temperature and final wet bulb temperature have been found, the psychrometric chart can be used. First, an assumed spray water temperature is located, like point *6* on Fig. 13, and a condition line drawn from point *1* to point *6*. The computed final wet bulb temperature corresponding to the assumed spray water temperature is then plotted on line *1-6* like point *7*. This process is repeated for a number of different spray water temperatures and their corresponding computed final wet bulb temperatures. A curve like the dashed curve of Fig. 13 can then be drawn through the points representing the various final wet bulb temperatures. The curve drawn through points *1*, *2*, and *7* of Fig. 13 represents the final wet bulb temperatures obtainable for various spray water temperatures for the constant given refrigerant temperature.

Obviously, if state *3* of Fig. 13 is to be maintained in the conditioned room, air must be obtained from the sprayed coil in a state which can be represented by a point on the moisture ratio line *3-5*. However, for a constant refrigerant temperature, the points representing the final wet bulb temperatures that can be obtained from a coil all lie along the curve through points *1*, *2*, and *7*. Consequently, there is only one final wet bulb temperature which lies both on curve *1-2-7* and line *3-5*. This final wet bulb temperature is represented by point *2* at the intersection of curve *1-2-7* and line *3-5*. Hence, for the conditions of this problem, the air must be supplied to the conditioned room in a state represented by point *2*.

The volume of air to be supplied must be determined according to the enthalpy change from points *2* to *3* by means of equation 9. After the required air quantity and the final wet bulb temperature—that is, the final enthalpy—have been found, the required area can be computed by means of either equation 3 [p. 167, April issue] or by the method illustrated in example 4 [p. 247, May issue].

The case in which the quantity of outdoor air is to be constant is illustrated diagrammatically on the skeleton psychrometric chart of Fig. 14. In this case, the initial enthalpy of the air entering the coil will vary with the quantity of air being circulated.

To solve the problem in which both the quantity of outdoor air and the refrigerant temperature are constant, it is necessary to first locate on the skeleton psychrometric chart of Fig. 14 point *3*, representing the state of the room air, and point *4*, the state of the outdoor air. Fig. 14 is similar to Fig. 9. Connect these two points by a straight line as shown. First assume some initial wet bulb temperature such as point *1* on line *3-4* and extend a condition line to the saturation curve at point *6*, which represents the temperature of the spray water. The method of determining the slope of line *1-6* is discussed in the next paragraph. A whole series of parallel straight lines are drawn, as illustrated in Fig. 14, through various assumed initial points along line *3-4*. In this manner the temperature of the spray water corresponding to each assumed initial state point can be found.

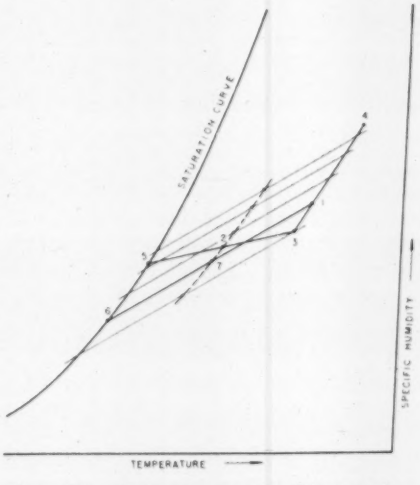


Fig. 14 — Diagrammatic illustration on psychrometric chart of method of determining final wet bulb temperature and cfm for installation in which both *volume* of outdoor air and refrigerant temperature are given

The slope of the parallel condition lines such as *1-6* of Fig. 14 can be computed by means of equation (g) of the footnote on p. 297 of the June issue. After the slope has been computed by means of this equation, the condition lines can then be drawn [see p. 60 of the author's book, Air Conditioning Analysis].

Knowing the initial enthalpy, the spray water temperature and the given refrigerant temperature, the method illustrated in example 4 can be used to solve for the ratio N_1/N. Then, by means of Table 4 [p. 246, May issue] the value of Z can be determined. Using equation 1 [p. 166, April issue] the value of Q/G can be found. Then, by means of equation 10 [p. 299, June issue] the values of h_2, the final wet bulb temperatures of the air, can be determined for each condition line. Each final wet bulb temperature is then located on the cooling line for which it was computed. As illustrated in Fig. 14, a dotted curve is then drawn through all of the final wet bulb points. The intersection of this curve with line *3-5* at point *2* of Fig. 14 determines the required final wet bulb temperature to which the air is to be cooled by the coil and the quantity of chilled air which must be circulated to the conditioned room.

After point *2* has been located, the area required to cool the air to point *2* can be computed by the method illustrated in example 4.

ANTHRACITE DISTRIBUTION REGULATED

A temporary distribution measure (regulation No. 2) to insure that every community will receive its fair share of the anthracite produced prior to the institution of a permanent wartime hard coal program was announced June 21 by Solid Fuels Administrator Harold L. Ickes.

"The safety of next winter's fuel supply requires that immediate action be taken to assure that each community will receive its fair share of the anthracite produced between now and the time a permanent program can be instituted," Administrator Ickes said. "The provisions of regulation No. 2 are designed to assure that this will be done. There is a grave responsibility upon the retail dealers within each community to see that the coal is fairly distributed among the ultimate consumers. I strongly urge that dealers, in so far as practicable, deliver to each domestic user no more than two-thirds of his annual supply prior to October, so that each consumer will have an opportunity to get his fair share of the available coal."

SAVE FUEL TO AID WAR EFFORT BY WIDER USE OF CONTROL

National District Heating Association Hears Reports on Many Topics at Annual Meeting Held in Pittsburgh

THE week of June 7 was "heating week" in Pittsburgh. The American Society of Heating and Ventilating Engineers held its semi-annual meeting (reported elsewhere in this issue) at the William Penn on June 7 and 8, the Smoke Prevention Association met at the William Penn the same week, and the National District Heating Association assembled on June 9 and 10 at the Hotel Schenley for its annual meeting. Heating men interested in both the ASHVE and NDHA gatherings found it of distinct advantage to have the two affairs in the same city, one immediately following the other but not overlapping. Many also took the occasion to drop in on sessions of the SPA.

Almost 150 members and guests registered for the district heating meeting to participate in a full program of discussions on wartime methods and problems. Use of building temperature control to save fuel was perhaps the most important of these topics. Philippe Schereschewsky, formerly of Paris, started things off with an international flavor by describing the Paris district heating system and giving some highlights of its construction and operation.

Comparing Steam Consumption of Buildings

One of the most interesting discussions comprised a study of the steam consumption of two theoretical buildings presented by F. Lee Rapson as a part of the report of the commercial relations committee, of which George H. Tuttle is chairman. Taking two buildings, one of 2,415,600 cu ft and the other of 251,580 cu ft volume, and using five different assumed exposures for each, he figured the steam consumption for each on the basis of pounds of steam per 1000 square feet exposure per degree day. Exposure was taken as the exposed wall (including glass) area plus one-half the roof area. The 10 values thus obtained, for the two buildings, each with five assumed exposures, were 18.3, 19.2, 17.5, 20.6, 15.9, 22.3, 22.3, 20.5, 22.7, and 17.5.

Mr. Rapson demonstrated that on the exposed area basis, the discrepancies in steam consumption figures are much less than when the steam consumptions of buildings are compared on a building volume basis as heating steam consumption is primarily a function of exposed building surface rather than building volume.

Additional evidence on the desirability of comparing building steam consumptions on the exposed area basis rather than the building volume basis was given by A. R. Mumford, in a paper which was part of the research committee report. He found, too, that steam consumption based on square feet of exposed area gave more consistent results than when based on cubic feet of heated space. About 100 buildings in seven different cities were included in his study; further investigation of the subject was recommended.

Fuel Conservation with Temperature Control

In a thorough and convincing talk on the application of temperature control to fuel conservation in large buildings, Henry T. Kucera stressed the importance to our war effort of allocating materials for unrestricted manufacture of such controls. Increased use of coal last year due to the war and to fuel oil rationing has made necessary the allocation of steel, bearing brass, etc., for construction of open top railroad cars. Based on the weight of materials to construct such a car, the amount of coal hauled per car per year, and the fuel savings that can be obtained in large buildings by the application of temperature control, Mr. Kucera said that materials allocated for manufacture of temperature controls can do 100 times the job they do when used to manufacture railroad cars. In addition, by conserving coal through temperature control, there are many other savings, such as manpower in the mines, trucking, etc.

Mr. Kucera said also that it is the larger buildings—industrial, commercial, and institutional—that represent the most attractive possibilities for conserving fuel because of the tremendous fuel needs of such structures. The widespread application of temperature controls to the heating systems in big buildings is the most feasible means of achieving fuel economy, he asserted.

In a comment on the subject of building temperature control for saving fuel, P. A. Hyde mentioned the case of a building in Akron which is served by district steam. This building has 24,000 ft of radiation and was heated by a one pipe Paul system. It was necessary to carry 9 psi steam pressure.

A 40,000 sq ft vacuum pump was installed which paid for itself the first season through better steam circulation. The building now has a subatmospheric heating system with two zone control. All ends of the mains were trapped and radiators were orificed. The $3600 cost of modernization was paid off in four years, and the system operates at 15 in. vacuum most of the time.

Mr. Hyde said that a most effective method of "postwar planning" for district heating companies is to reduce steam consumption of their customers *now* by wide application of temperature control equipment. In this way, the district steam companies will not lose customers to other fuels after the war is over.

In the report of the commercial relations committee, Mr. Tuttle presented some results of temperature control installations on district heating customers' premises. The steam savings effected by 36 installations averaged 14 per cent, and the average number of years required to pay off the investment was 4.7.

14% Saving

Steam savings effected by 36 installations of temperature control in customers' premises averaged 14 per cent and the number of years required to pay off the investment averaged 4.7, according to one report presented at the NDHA's meeting last month. In another report, it was shown that allocation of critical materials for manufacture of control can do 100 times the job if the materials were devoted to construction of railroad cars for hauling coal.

Many other reports on wartime problems featured the meeting. An interesting presentation showed that steam consumptions of different buildings can logically be compared on a basis of "pounds of steam per 1000 square feet of building exposure per degree day," using the total wall area (including glass) plus one-half the roof area as the exposure area of the building.

A number of the speakers referred to the many conversions to district steam from fuel oil, due to the oil rationing program. In New York, some 300 buildings have changed over to street steam service. There was much discussion of the possible place of oil as a building heating fuel in the postwar period, and the opinion was expressed that it might be restricted because of the many new uses for our petroleum resources. The matter is of importance to the steam utilities from the standpoint of the possible number of re-conversions to oil from central steam when oil rationing is no longer necessary.

Many Committee Reports

James E. Harris gave the report of the insurance committee, discussing insurance problems of small companies. The discussion included fire protection, performance bonds, boiler and machinery insurance, insurance provisions in contracts with the American Boiler Manufacturers Association, hold harmless agreements, and insurance required of contractors and subcontractors.

J. Earl Seiter presented the rates and regulations committee report. He urged a rate study to develop a new rate which would be fitted to the district heating industry.

The report of the sales development committee was presented by R. D. Martin; he told of the growth of business of the New York Steam Corp. due to the fuel oil situation in the east. David W. Loucks stressed the necessity of efficient service and continued customer relations as a postwar measure, and Harry A. Weitzman suggested studies of fuels, rates, and other conditions which would have an influence on the postwar business of the industry. He urged that research be featured.

According to Vernon F. Alley, the problem of wartime sales is to retain customer contacts and assist customers and contractors in obtaining sufficient materials for maintenance.

The meters and accessories committee under the chairmanship of A. W. Wieters, presented three papers: Unusual Meter Maintenance Due to War Conditions, by Richard H. Brown; Testing Condensate Meters by Testing Drums Only, by J. C. Butler; and Methods and Materials Used in Cleaning Meter Drums, by Randall J. Bodin.

W. Wisschusen presented the operating statistics committee report for Thomas P. Brown, the committee chairman. The analysis showed an increase in sales volume and revenue for practically all companies, and colder weather in most districts. There was a continued increase in cost of fuel and a decrease in the number of employees, with considerable increases in hourly rate and total hourly cost.

John F. Collins, Jr., read his progress report on weather statistics, stating how the NDHA, with other interested societies and associations, was working on a standard method of reporting weather statistics in cooperation with the U. S. Weather Bureau. Varying methods of determining degree days in larger and smaller cities have caused confusion in some areas.

The report of the chemistry committee was given by Leo F. Collins. In a paper entitled Some Unusual Uses of Steam and Condensate, Louis Shnidman suggested the purging of tanks of inflammable gases, the decontamination of buildings of war gases, etc.

Dr. D. S. McKinney described some of the research work being done at Carnegie Tech in connection with the venting of gases from steam utilizing equipment. Max Hecht described briefly the desirability of having standards of water analysis and water testing methods.

R. B. Donworth presented the station engineering report. His first paper had to do with chemical warfare as it affected plant operation. Mr. Donworth recommended that in case of gas warfare, plant operating personnel be scattered to reduce casualties. He also recommended well equipped decontaminating crews. Considerable discussion followed Mr. Donworth's presentation. The report of the committee also included a summary of the principles for safe storage of coal.

Major G. K. Saurwein gave the report of the distribution committee. The first paper was Wartime Conservation of Critical Materials in Constructing Underground Steam Lines. A. A. Sellke showed how welding flanges and expansion joints could be fabricated. He also described a concrete manhole cover which has been developed to conserve critical materials.

Another paper, which was not read, gave plans for distribution system protection and operation in event of air raids or other war incidents. This paper covered the plans for protection of several companies.

W. W. Stevenson told how his company had repaired damage to underground piping insulation by filling the conduit with a lean mixture of concrete.

Methods of mechanical drainage of steam manholes and tunnels, and methods of protecting manhole equipment against corrosion, were presented by Paul Chenzoff.

Following a short description, a colored motion picture was shown of the solid pour steam pipe conduit recently installed in Detroit. The feature of this conduit is that the concrete is poured in one operation directly around the waterproofed jacket of the insulation. Considerable discussion followed this moving picture.

Walker Made Honorary Member

A feature of the meeting was the award of honorary membership in the NDHA to J. H. Walker, "whose achievements in his chosen field are beyond ordinary measure."

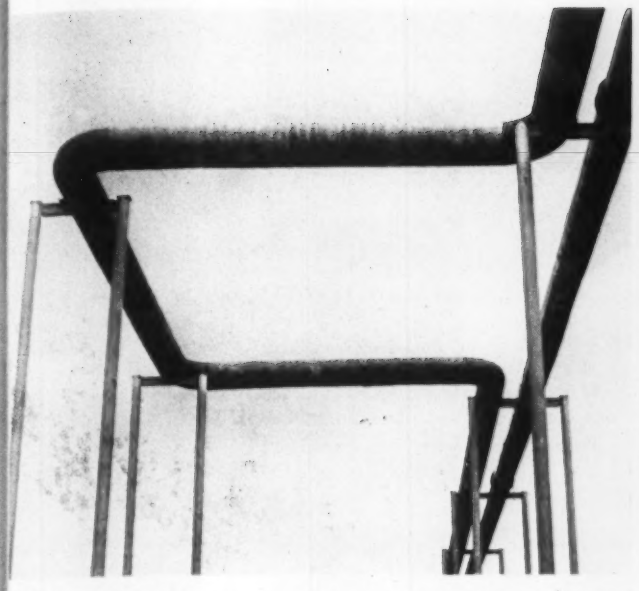
Officers elected for 1943-44 comprise J. J. Schenk, president; Sterling S. Sanford, first vice president; Ray M. McQuitty, second vice president; John F. Malone, third vice president; and William A. Herr, L. C. Killen, and R. D. Martin, executive committee. John F. Collins, Jr., is secretary-treasurer of the NDHA and the headquarters office is at 827 N. Euclid Ave., Pittsburgh.

WHY STOKERS ARE ESSENTIAL IN OUR TOTAL WAR PLAN

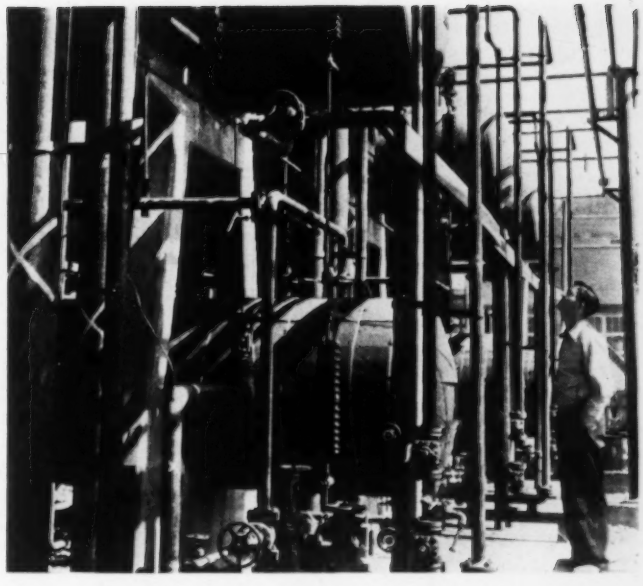
IN A "report to the War Production Board" on the stoker industry today, recently issued in printed form by the Stoker Manufacturers' Association, there is presented a convincing list of reasons why mechanical coal burning equipment is essential in our war effort. These reasons are that stokers burn bituminous or anthracite coal or lignite; nearly a million stokers are in service; stokers use less coal; they use local coals (and thus conserve transportation and manpower); they save labor required for heating plant operation; greater steam output may be obtained with stokers as compared to hand firing; stokers save critical materials (by stepping up steam output of present boilers); they save oil and gas (through conversion); stokers help to reduce and abate smoke: and, finally, "stokers save money for bonds and taxes."

To avoid serious delays in production and interruptions to critical manufacturing schedules, it is necessary that sufficient materials be allotted to the stoker industry to allow an unrestrained flow of stoker repair items to users, says the report.

The report concludes by saying that the stoker industry made unusual progress during the depression years if for no other reason than that stokers saved fuel and money then. Therefore, in wartime the stoker is a far more valuable product, even if measured only in terms of its inherent nature to conserve fuel. As the war lengthens and the need for more and more production and more and more power and steam and heat are necessary, stokers must fit more carefully into the pattern of total war planning being undertaken by many of the nation's leading business executives in cooperation with federal agencies.



STEAM. The synthetic rubber plant operated for the government by United States Rubber Co. at Institute, West Va., will consume 190,000 lb per hr of steam. The full capacity of the plant will produce enough synthetic rubber to make 63,000 passenger car tires daily

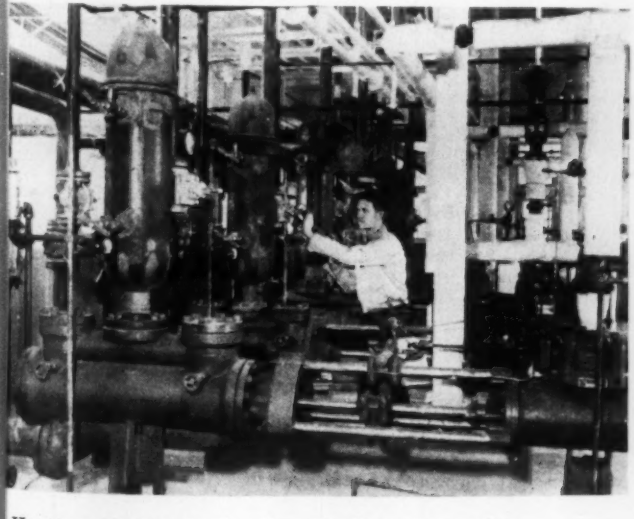


BUTADIENE PURIFICATION. An inhibitor is added to butadiene in storage to prevent premature polymerization. The inhibitor must then be removed in the chemical apparatus shown here before butadiene is pumped to the reactor area

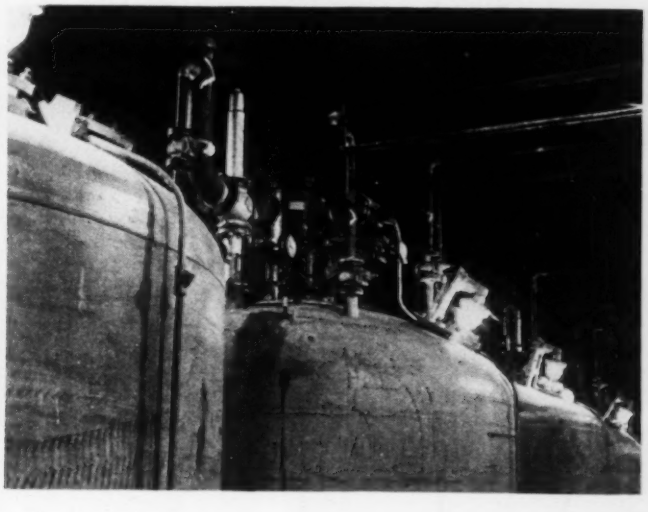
CAMERA!

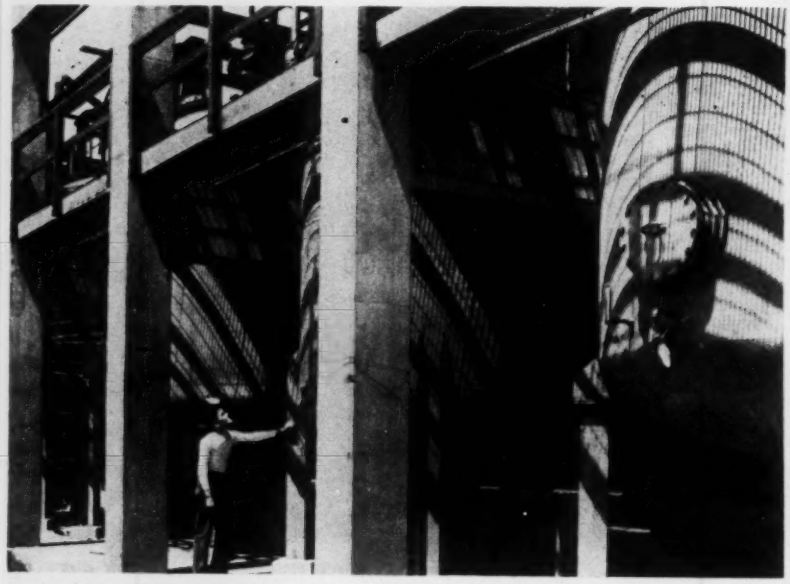
PIPING . . . PIPING . . . and more PIPING —plus tanks, pumps, valves, flow control first impression of a synthetic rubber plant

TRANSFER PUMPHOUSE. The raw materials, butadiene and styrene and many special chemicals, are moved by pumps and pipe lines from storage to the reactor areas



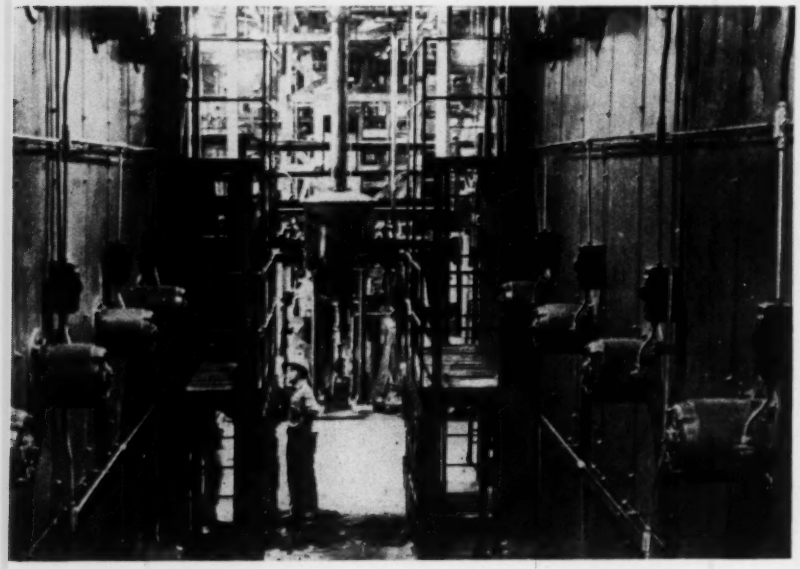
REACTORS. The actual making of synthetic rubber is called polymerization and takes place in large glass lined vessels called reactors. In this plant there are a total of 72 such reactors. [Continued on next page]

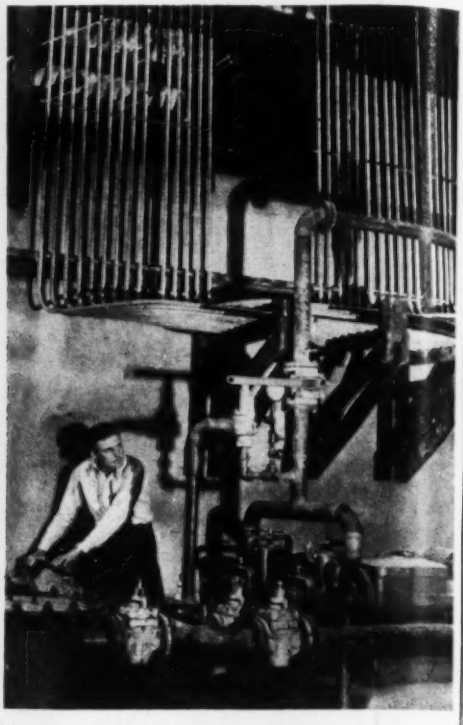




BLOWDOWN TANKS. When polymerization has reached the proper point, the batch is blown down by butadiene pressure to the blowdown tanks, where the reaction is arrested

WASHING. After certain dilute chemicals have been recovered, the synthetic rubber in the form of flocs or crumbs is washed

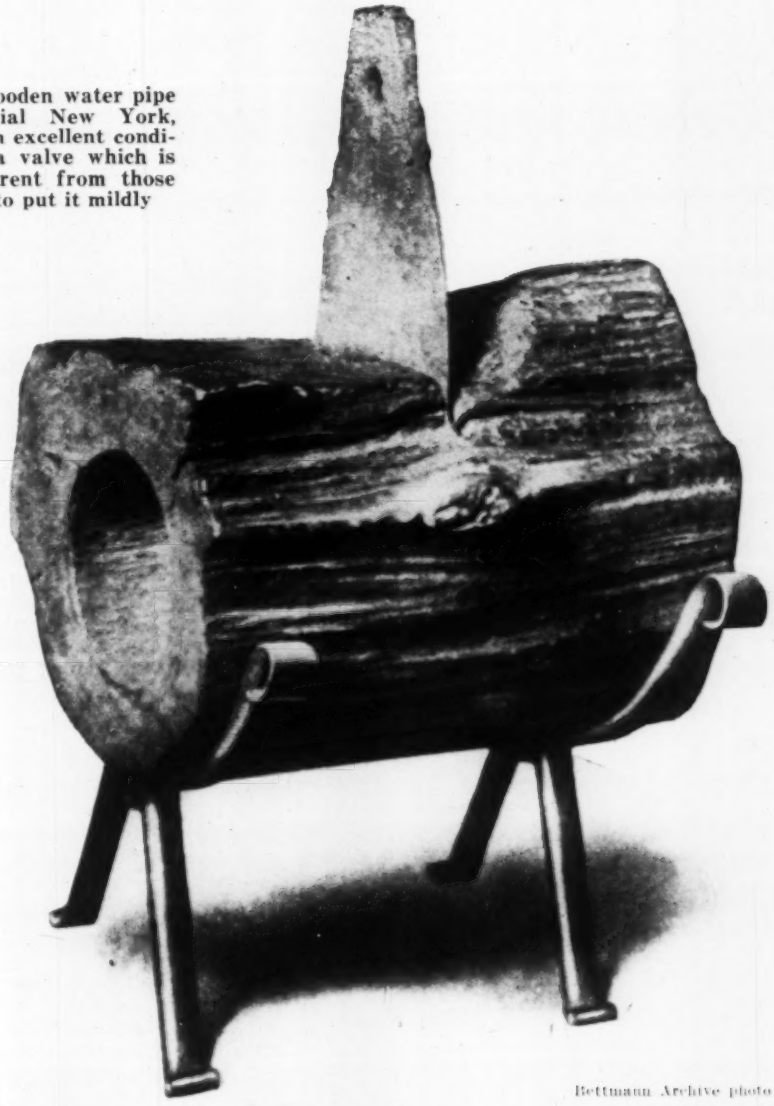




BLENDING. Many batches of synthetic rubber latex are batched and blended in twelve 30,000 gal concrete storage tanks. This blending assures uniformity of the product. The rubber content of the synthetic rubber latex is then coagulated and separated in the form of flocs or crumbs

PACKAGING. The loaves of baled rubber are packed in cartons in order to protect them and to avoid loss in shipment. At full operation, the plant will produce 9000 such rubber loaves daily, the equivalent of one-sixth of our country's normal peacetime production for all purposes

DRYING (left)—Buna S synthetic rubber is dried by passing back and forth three times in 12 enormous dryers. At full operation these dryers will evaporate 160 tons of water per day



A section of wooden water pipe used in colonial New York, found in 1900 in excellent condition, showing a valve which is somewhat different from those used today—to put it mildly

Bettmann Archive photo

A History of Piping

Up to the last 125 years or so, the history of piping has been the history of water and sewage systems, and the principal piping developments were in water and sewer pipe.

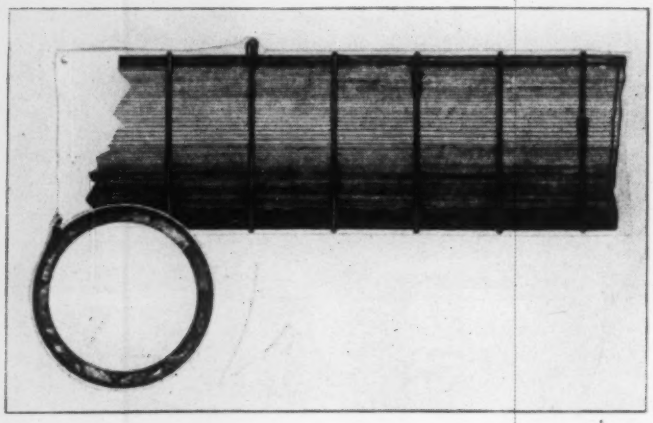
We get an idea of how dark the Dark Ages were when we observe how long it took to recover from them, once the building of water and sewer systems of present day cities was begun. Plagues swept over Europe (and, later, America) for a thousand years, striking hardest in poverty-stricken areas where filth was greatest, before people—in sufficient numbers to do something about it—finally associated pestilence with impure water and improperly removed sewage. Even then it was centuries before water and sewage facilities could be called adequate in the most progressive cities. It was not until the latter half of the past century that the most progressive cities could be said to have struggled back to where the ancient Romans had left off in providing adequate water supply and sewage disposal for poor areas as well as rich.

In earliest times London, like European cities founded during or after the Dark Ages, got water from wells, rainwater cisterns, rivers and springs. People who had no access to such sources bought river water from peddlers for drinking and cooking. For baths, too? No. The great novelist Thackeray once remarked "There is no doubt about it, gentlemen, our ancestors were a filthy lot."

In the years between 1515 and 1530, Belgrand, commissioned by the king of England, built the first water piping system in London. It seems that Belgrand was a better advertising man than waterworks engineer for he made a great to-do about duplicating and testing Roman lead pipe and using such pipe in his system. But his water lines could not have amounted to much since they are not even mentioned in a Survey of London, made at the end of that century, which describes water sources as "the Thames, its tributaries and wells, the water fetched by servants."

In 1583 a Dutchman, Peter Morice, completed the first span of the London bridge, which included a large waterwheel that operated water pumps. Belgrand, to whose pipes the new pumps were connected, promptly claimed that "Now London has a modern water system."

However, the Thames water tasted awful, especially because the tide kept washing the sewage back to the city. Consequently, in 1609 to 1613, Sir Hugh Myddleton built the "New River." It was a hollow log pipe line that brought water a dozen miles by gravity from springs near Hertford.



Way Back When

It's always interesting to review the beginnings of an art as important to mankind as is piping. In this, the third of a group of articles being published in Heating, Piping & Air Conditioning, M. A. Hasselmann—of Tube Turns, Inc.—continues his description of the development of our "greatest transportation system."

Wood stave piping was used extensively in America during the middle of the last century for water mains and sewers

Elm trunks were bored with a 6 in. hole—a few sections of this line were recently unearthed. Myddleton's claim of having laid 400 miles of distributing mains seems to have been stretching the slow gravity flow of the 6 in. aqueduct pretty thin. The company laid larger mains of cast iron in 1812, and may have had 400 miles of mains by that time.

There is no reason to believe that Myddleton's water company used any of the piping of Belgrand's, or that later water companies used any of Myddleton's. It was not until 40 years ago that the then numerous water companies of London (eight) were merged into one metropolitan system.

The Great Fire of London, 1666, destroyed most of the city's wood and lead water piping, just when it was needed most, and the water companies began experimenting with cast iron pipe. But it was not until 1744 that the Chelsea Water Co. of that city began replacing with cast iron. At that time the continental cities of Wulberg, Bruehl, Rheims, and Clermont-Ferrand were also installing complete cast iron water mains.

Lead the Standard Piping Material

Lead was the standard material for water lines from the street to and through the house until the latter half of the 1800's. It was too expensive for mains. The cost of lead pipe was reduced by a development in 1760 which provided for making continuous lead pipe to be transported to the installation in reels. An iron exterior mold and an iron interior core mold were mounted in permanent position, the space between the two molds closed at one end. Through a hole in the top of the exterior mold the molten lead was pored. When the lead cooled the cast section of pipe was pulled almost all the way out of the open end of the mold. The hot lead in the next casting operation fused with the previously formed pipe.

In 1790 John J. Wilkinson, an Englishman, invented the first mechanism for rolling lead pipe: A "punch" or long rod of uniform diameter was forced into a mass of lead which, between the rollers of a reversing rolling mill, was worked back over and around the punch until a wall thickness of the desired diameter was obtained and the punch removed. In 1804, Alderson, another Englishman, formed a blunt, thick lead pipe and stretched it to the desired inside diameter and wall thickness. In 1820, Thomas Burr developed a hydraulic press for forcing cold lead through a die and around a mandrel inserted in the die. This is the method used today to make lead pipe. A similar mechanism pressing hot lead into pipe, was invented in 1822 by John Hague of England, but this method has largely been abandoned.

Bored Log Piping in Boston

The Pilgrim Fathers had not landed very long—32 years—until they built the first water system in their largest city, Boston. This was a bored log aqueduct that brought water by gravity from a spring to a trough or fountain at the center of the city, from which it was fetched by buckets. In 1732 the Moravian settlers of Schaefferstown, Pa., built a bored log aqueduct from a fine spring outside the city.

The first water system in America as we know it today was built at Bethlehem, Pa., 20 years later. With a 5 in. lignum vitae pump operated by a waterwheel, water was pumped from a spring through bored hemlock, poplar, and gum pipes to a tank 70 ft high in the center of the town. Bored log distributing lines were used, with lead pipes connecting to the homes. The builder, Hans Christianson, a Danish millwright and mechanical genius, was not satisfied with his system although in its first test it threw a jet of water higher than the houses of the town, and immediately began the planning and construction of a larger and better plant, completed eight years later.

In 1658 the Dutch dug the first public well in New York City. Just before the Revolutionary War a private company, headed by Christofer Colles, dug a pretty good well, a 550,000 gal reservoir, and a distributing main. A Newcomen steam engine pumped the water. The project was abandoned soon after completed, due to the conflict.

In 1797 Portsmouth, N. H., built a bored log system which, dug up 77 years later, had worn (as indicated by the knots, which did not wear) from a 5 in. inside diameter to 8 in. However, such long service was exceptional. Some soils, especially alkaline, caused rapid deterioration of wood piping and maintenance was extensive. There was trouble with joints, especially when a considerable degree of mechanical pressure was involved. During the first half of the last century, however, most cities, confronted with the choice of large initial investment in iron mains or smaller investment in wood mains with the risk of higher maintenance costs, chose the latter.

In 1799 Boston, New York, and Philadelphia got busy building bored log water systems. Boston formed its Aqueduct Co. that piped water by gravity three miles from Jamaica Pond through three lines of pipe, two with a 4 in. bore and one with a 3 in. bore. New York founded its Manhattan Co. headed by Aaron Burr, pumping water from a well and using the reservoir built by Colles' short-lived company 25 years before, through wood mains on some of the main streets of the city. However, this company was only slightly interested in providing water and primarily interested in running a bank which was permitted by a clause in its perpetual charter "as a means of investing the company's surplus funds."

The first water mains laid by Philadelphia were bored logs of 6 in. inside diameter. Handmade wrought iron tubes, 6 in. inside diameter and 6 in. long, were inserted at the joints and two wrought iron bands, drawn up with bolts, reinforced each joint—one on each of the joining sections.

A World of Wood

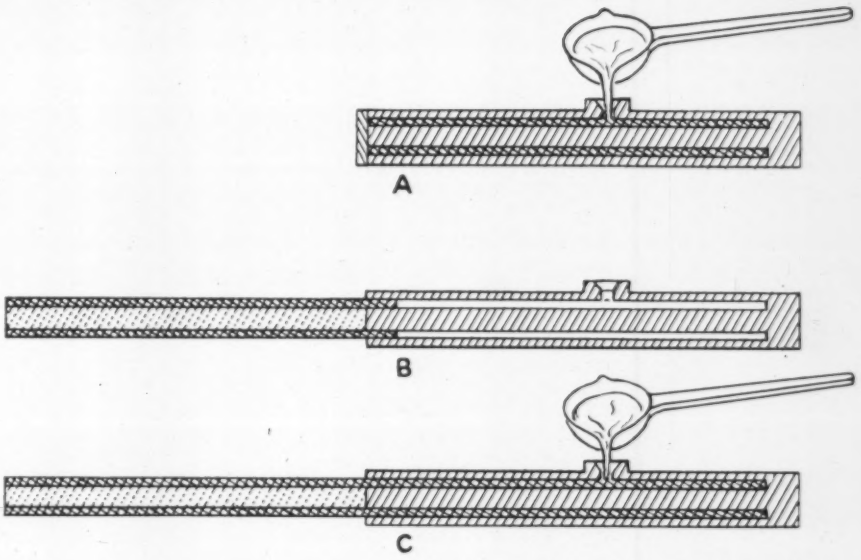
It is difficult for us today to imagine the world of wood that existed in those days. Philadelphia had to pump its water with two steam engines that were made mostly of wood; one pumped the water out of the Schuylkill river and into the center of the city, the other pumped it

into wood tanks about 50 ft above the ground. The flywheels, lever beams, shafts, and arms of these engines ,the copper lined, 6 ft stroke, piston type water pumps, the cisterns below and pressure tanks above, were all wood. Even the boilers were of wood, being 9 ft by 15 ft by 9 ft high and made of 5 in. thick white pine planks. They had wrought iron fireboxes with cast iron flues inside. Since wrought iron could then be obtained in untrimmed sheets (purchaser squared it down) that finished no larger than 15 in. by 3 ft long, the firebox was a riveted patchwork with flues of cast iron pipe.

Benjamin Franklin recommended for Philadelphia an aqueduct from the Wissahickon creek, and willed money for the building of the needed dam. The project would have provided a single, adequate water supply until long after the Civil War, gravity flow and very inexpensive, had the city built the necessary aqueduct from its own funds.

First Iron Mains in America

It was soon learned that the pressures necessary to force water over the mains of a large city meant trouble if log piping were used and the city of Philadelphia, as early as 1802, was making a test installation of cast iron pipe. To test a type of connection, 14 sections, 6 ft long, imported from England, were laid in the central part of the city. Two years later, an installation of 4000 ft of iron pipe was made in Water street. This apparently was not satisfactory, probably due to faulty joints, and later a representative was sent to inspect the cast iron water mains in London. As soon as possible after the war of 1812 to 1815, an installation of imported cast iron pipe, similar to that used today, was made. It was successful and the following year Philadelphia decided that henceforth it would use nothing but iron mains.



The process of casting continuous lead pipe, developed in 1760. (A) Cross-section of mold and original casting. (B) Pulling cast section almost out of mold. (C) Casting second section which fused one-piece with first section

In 1848, a Dr. Angus Smith developed an interior bituminous coating that minimized tuberculation of cast iron pipe. With it, this material became the principal one for water main piping.

Continuous Stave Piping

Eventually the use of wood for water mains developed the continuous stave piping which made possible larger diameters without the use of huge logs. For such piping, pine boards 2¾ in. wide and about as thick were usually used, beveled to form the desired diameter and held with wrought iron bands. Wyckoff, at Elmira, N. Y., was reputed to make the best wood stave piping in 1850 and his competitors' imitation of him improved the performance of all stave piping.

A 6 in. stave line with 4 in. walls was built at Manchester, N. H., as late as 1867, but in general the use of wood water mains during the latter third of the 1800's was confined to the west, where wood was plentiful and iron products imported and expensive. In 1884 Denver built a 48 in. stave main.

Stave piping as large as 14 ft in diameter is of course used today for water, irrigation, and hydro-electric systems. Louisville, Ky., has a section of wood stave sewer in use today.

COST OF AN ARC WELDED PIPE LINE

AN ALL arc welded steam line, 8 in. in diameter and 2000 ft long, at a large railroad shop is designed to carry 34,000 lb per hr of steam at 145 psi initial gage pressure and 75 F superheat.

The plant contains a 36 pit locomotive repair shop and a 49 stall engine terminal round house. Approximately one heavy repair locomotive and one-half light repair locomotive are turned out each day at the locomotive repair shop and from 140 to 150 locomotives are handled at the round house each 24 hr.

Formerly two separate power plants served these shops, one located at the locomotive shop and the other at the round house. With the construction of the line in question, the power plant at the round house was shut down; one 500 hp boiler in this plant was retained for use in emergencies and during extremely cold days in winter. A net annual saving in operation of approximately $10,000 is made by this arrangement.

Problems incidental to construction of the 2000 ft pipe line required careful planning, as it traverses through approximately 700 ft of tunnel, 360 ft in underground conduit, the balance being vertical risers and overhead in buildings. A portion of the underground line in conduit crosses under two railroad tracks and one trucking road.

The line is constructed of 8 in. lap welded steel pipe, 28 lb per ft, 0.322 in. wall thickness, and was supplied in 20 and 40 ft lengths, with plain ends beveled 37½ deg for welding.

All elbows are seamless steel welding fittings and lateral outlets are also welding fittings. Gate valves are 250 psi ferro-steel and flanges are 300 psi, forged steel, slip on type. Special ⅞ in. steel studs were used in all flanged connections and flanged fittings.

Great care was exercised in determining the number, kind, and location of expansion joints. At all locations, except in the tunnel, long radius expansion loops and U bends were used; a 300 psi working pressure, cast steel, double, internal-external guided type expansion joint was utilized in the tunnel.

The line is insulated with sectional covering, 2 in. thick; the portion underground is encased in spirally corrugated iron conduit, the outside of which was treated with asphalt and felt wrapped.

The complete cost of installation for this 8 in. pipe line was approximately $14,000. The cost of welding a joint, of which there are 110, was $1.50, broken down as follows: power, $0.25; welding rod, $0.21; and labor, $1.04. Cost of covering (material and labor) per joint was $1.00.

The job has proved so successful that we contemplate welding all major steam line work in the future.

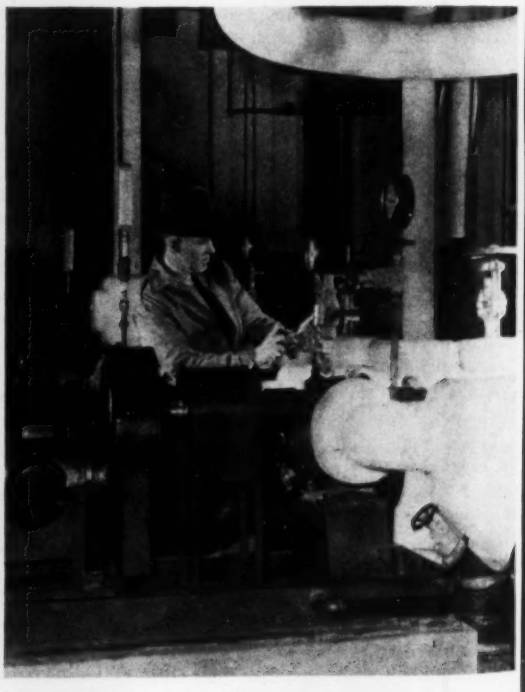
From a study submitted to the James F. Lincoln Arc Welding Foundation by William A. McGee, mechanical engineer, New York Central Railroad Co., in its recent $200,000 industrial progress award program.

Workman atop this 18 ft framework is making the final weld before setting in banks of electrostatic air cleaner cells which will remove particles of dirt from the air being sucked into a huge turbo blower in the power house at the new Kaiser Co. steel mill in California. This is said to be the first time in steel mill history that an electric air cleaning apparatus has been used to keep the rotor blades free from sludge formation, thus reducing maintenance work and enabling more efficient operation. Air intake shutters, through which 90,000 cfm of air will pass, are in background

Electric Air Cleaning Used at Kaiser's

Westinghouse photos

Seven cooling towers in this bank remove heat from circulating water used by the turbine condensers. Cooling action is obtained by driving large six bladed plastic fans 1465 rpm with 30 hp splashproof induction motors. This induced draft cools 12,000 gpm



Geared fuel oil pumps are driven by direct connected gear motors at the new Kaiser steel mill, which went into operation early this year. The fuel oil is used to generate steam to operate the turbo blower which supplies blast furnace air

Heating · Piping · Air Conditioning

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Journal Section

Heat Transmission Through Insulation as Affected by Orientation of Wall

By Frank B. Rowley* and C. E. Lund**, Minneapolis, Minn.

SUMMARY — **Comparison has been made between calculated and test values of *U*, the overall coefficient of heat transmission, for three groups of walls with and without mineral wool insulation, with horizontal and vertical orientation of wall. Mineral wool insulation in granular, bat, and blanket form was applied by hand and by machine blowing. By considering parallel heat flow through insulation and through the framing members accurate values of *U* were computed which checked experimental values.**

THE LAWS governing the thermal conductivity of insulating materials and of insulated walls have for most conditions been rather definitely established. It is usually possible to calculate with reasonable accuracy the overall thermal conductivity of a wall, providing the thermal properties for the various materials of construction are known. There are, however, some conditions under which the calculated results may be questioned. This may be due to some indefiniteness as to the properties of the materials or to differences in methods used in making the calculations.

Take, for example, a wood structure in which insulating material is placed between the framing members. For practical purposes in making the calculations it is often assumed that the insulating material covers the full area of the wall and the heat resistance through the studs is considered the same as that through the insulation. For relatively thin layers of insulation, this method would result in a calculated conductivity value for the wall which would be too high, whereas for relatively thick layers of insulation, it would result in a calculated overall conductivity which would be too low. For certain thicknesses of insulation in which the insulating value of the material between the studs would be equal to that of the studs, the calculated results should check with the test results. A more accurate method of calculation is to consider parallel heat flow through the framing members and through the insulation. In making calculations on this basis, the question arises as to how effective the full thickness of the framing members may be. One method is to assume a thickness equal to that of the insulation, and another is to use the full thickness of the framing members. Neither of these methods is absolutely accurate for all thicknesses of insulation in combination with a given thickness of studs or framing members.

Another question that may be raised in connection with porous or fill insulation is that of the possible effect of convection currents on the apparent thermal conductivity of the material and as to whether such possible convection currents might affect the heat flow differently for different orientations of the wall and for different directions of heat flow through the wall.

Density and fibre size of insulating material are also factors which affect their thermal conductivity, but for practical purposes, average values must be used in calculating the coefficients of insulated walls.

The purpose of the research reported in this paper was to determine some of these factors and to compare tests with calculated results for different applications of insulating material in framed walls and for different orientations of the wall. The results here reported are confined to mineral wool insulation; however, other types of insulating materials were included in the tests, and the comparative results between calculated test values were found to be the same. In making the tests a standard hot-box apparatus was used

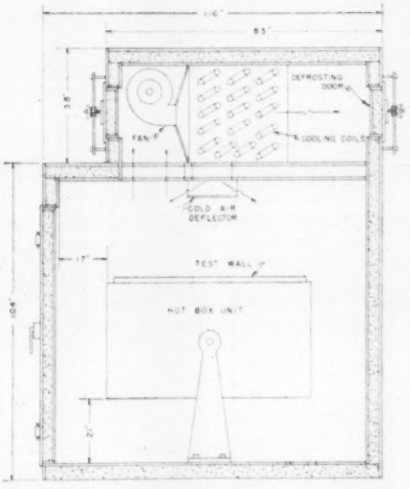

Fig. 1—Cross sectional view of cold room showing test box in position for conducting heat vertically upward through wall

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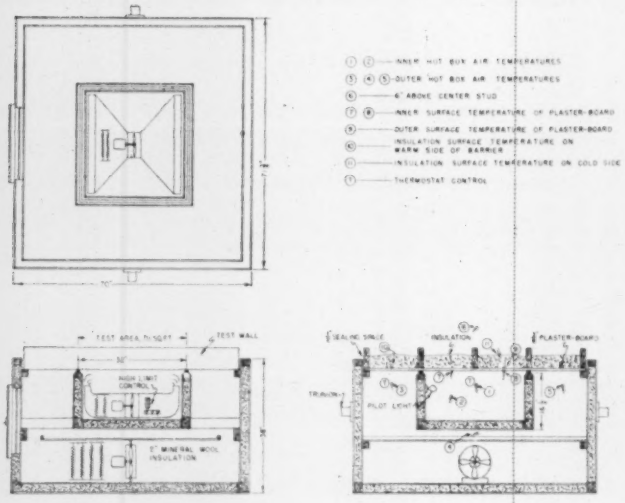

Fig. 2—Details of test box with test wall in place

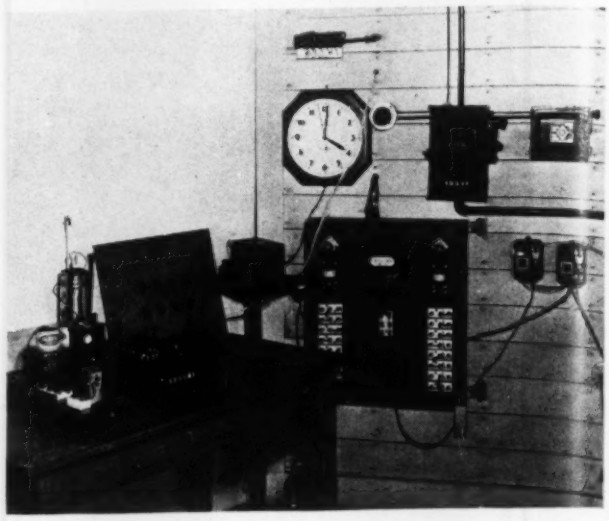

Fig. 3—Control panel and test instruments

and was so constructed that it could be rotated to place the wall either in a horizontal position with heat flowing upward or in a vertical position with heat flowing horizontally. Frame walls were used with both 2 x 4 in. and 2 x 6 in. framing members, and in some instances the framing members were omitted over the test area to eliminate their effect upon the thermal value of the insulation. Mineral wool was used in granular, bat, and blanket form, and in thickness varying from 2 in. to 6 in. Various methods of application were used as described later.

Test Apparatus

The test apparatus consisted of a standard or guarded box construction. It was designed for a test wall 5½ ft square, mounted on trunnions so that the wall could be rotated to either a vertical or horizontal position, and placed in a cold room, the temperatures of which could be controlled to —10 F. Fig. 1 shows a cross-sectional view of the cold room with the test equipment installed. Fig. 2 gives the details of the test box with the test wall in place, and Fig. 3 is a photographic view showing the control panel and instruments located outside of the test box.

Referring to Fig. 1, which is a cross-sectional view through the cold room showing cooling coils and circulating fans above, the hot-box is shown in a horizontal position with test wall in place. The low temperature in the room is maintained by circulating the air through the cooling coils and controlling the temperature through the compressor.

Fig. 2 shows the plan for the test box with the wall removed, together with the two sectional views with test wall in position. The sectional views

Table 1—Summary of Test Results

Test No.	Description of Test Section	No. of Tests	Wall Position	Insulation Thickness Inches	Insulation Density lb/cu ft	Conductivity k[1] Test[2]	Conductivity k[1] Corrected[3]	U Value Test	U Value Corrected[4]
	Group 1: ⅜ in. Gypsum Plaster Board, 2 x 6 in. Joists								
1, 26, 33	No insulation	3	Horizontal	...	...	....	....	0.817	0.958
19	2 in. Hand applied granular mineral wool	1	Horizontal	2.12	6.05	0.340	0.288	0.139	0.137
2, 3, 4, 12	3 in. Hand Applied granular mineral wool	4	Horizontal	3.15	6.60	0.341	0.289	0.102	0.101
5	3 in. Hand Applied granular mineral wool with wire covering	1	Horizontal	3.00	6.62	0.343	0.291	0.101	0.102
6	3 in. Hand Applied granular mineral wool with wire covering	1	Vertical	3.00	6.62	0.343	0.291	0.098	0.100
35	3 in. Machine blown granular mineral wool	1	Horizontal	3.21	5.90	0.308	0.252	0.096	0.087
7, 8	4 in. Hand Applied granular mineral wool	2	Horizontal	4.05	6.14	0.373	0.326	0.084	0.084
10	4 in. Hand Applied granular mineral wool with wire covering	1	Horizontal	4.05	6.14	0.359	0.309	0.082	0.081
11	4 in. Hand Applied granular mineral wool with wire covering	1	Vertical	4.05	6.14	0.359	0.309	0.080	0.081
9	4 in. Hand Applied granular mineral wool with paper covering	1	Horizontal	4.05	6.14	0.369	0.320	0.080	0.081
14, 15	4 in. Machine blown granular mineral wool	2	Horizontal	4.04	5.57	0.358	0.308	0.082	0.081
16, 18	4 in. Machine blown granular mineral wool with wire covering	2	Horizontal	4.07	5.70	0.341	0.289	0.076	0.077
17	4 in. Machine blown granular mineral wool with wire covering	1	Vertical	4.09	5.84	0.343	0.291	0.077	0.077
36	4 in. Machine blown granular mineral wool with 1 in. flooring	1	Horizontal	3.87	5.82	0.288	....	0.069	0.069
34	4 in. Machine blown loose mineral wool	1	Horizontal	4.14	6.39	0.377	0.329	0.083	0.08
37	6 in. Machine blown granular mineral wool with 1 in. flooring	1	Horizontal	5.125	7.27	0.323	....	0.059	0.059
39	3 in. Mineral wool bats, barrier lapped on warm side	1	Horizontal	3.478	3.67	0.346	0.295	0.092	0.090
21	3 in. Mineral wool bats, barrier laid on warm side	1	Horizontal	2.646	2.24	0.316	0.261	0.106	0.106
22	3 in. Mineral wool bats, barrier laid on warm side	1	Vertical	2.646	2.24	0.303	0.247	0.102	0.102
27	4 in. Mineral wool bats, barrier lapped on warm side	1	Horizontal	3.89	2.99	0.359	0.309	0.085	0.084
28	4 in. Mineral wool bats, barrier lapped on warm side	1	Vertical	3.89	2.99	0.378	0.330	0.088	0.088
20	4 in. Mineral wool bats, no barrier	1	Horizontal	3.99	1.77	0.354	0.304	0.082	0.081
	Group 2: ⅜ in. Gypsum Board, Joists Omitted in Test Section								
30	2 in. Hand Applied granular mineral wool	1	Horizontal	1.906	6.36	0.303	....	0.136	0.139
46	3 in. Hand Applied granular mineral wool	1	Horizontal	2.635	6.80	0.311	....	0.107	0.106
32	3 in. Hand Applied granular mineral wool	1	Horizontal	2.940	6.05	0.327	....	0.101	0.101
29	4 in. Hand Applied granular mineral wool	1	Horizontal	3.875	6.67	0.307	....	0.075	0.074
48	6 in. Hand Applied granular mineral wool	1	Horizontal	5.125	7.13	0.325	....	0.058	0.060
	Group 3: ⅜ in. Gypsum Board, 2 in. x 4 in. Joists 4 in. deep								
38	4 in. Machine blown granular mineral wool	1	Horizontal	3.625	5.76	0.356	0.303	0.089	0.089

NOTE:
[1]Conductivity k is based on differences of overall test coefficients of insulated and non-insulated walls.
[2]Test coefficient includes studs and is based on thickness of insulation as applied.
[3]Corrected on basis of parallel heat flow through insulation and joists and on actual thickness of insulation as applied.
[4]Corrected to still air on inside surface and 15-mile wind velocity on outside surface of wall.

show the arrangements of the inner and outer test boxes, the heating element, the fans for circulating the air within both boxes, and the location of the various thermocouples used in the test apparatus, and throughout the test wall. Heat is furnished to the outer box by electric heating elements shown at the bottom of the sectional view, and the air is circulated by a fan as shown. Heat is supplied to the inner box by heating elements which are encased in a circulating duct, the warm air being circulated by a fan over the surface of the test wall. The temperatures of the air within the two boxes are controlled to 70 F by two constant temperature regulators which in turn control the electrical input to the heating elements. All of the current supplied to the inner heating box is metered and used in calculating the thermal coefficients of the walls. All of the temperatures are taken with copper constantan thermocouples and Leeds & Northrup potentiometer. The inner or test box proper is 32 in. square in order to coincide with the space between two 16 in. spaced framing members, and thus give average results over the test area including the studs or joists with the insulated section. All thermocouples and electrical leads are carried to the outside and connected to the control panels shown in Fig. 3.

Test Procedure

In making a test, a 5½ ft square wall was constructed and placed in position to seal the two open faces of the inner and outer boxes as shown in Fig. 2. The test box was then set in either a vertical or horizontal position as required for the test, and the temperatures within the inner and outer test boxes were brought to 70 F by the automatic temperature control and that in the cold room was brought to —10 F by a separate automatic control. These temperature conditions were maintained until uniform temperature gradients were established throughout the test wall and box, after which records were kept of wall temperatures and of the heat supplied to the inner test box for a sufficient length of time to assure uniform and accurate test conditions. The uniform temperature period usually averaged eight hours, although it was not definitely set. From the constant temperature and electrical meter reading, the thermal conductivity coefficients were calculated.

Description of Walls Tested

Insofar as the framing construction is concerned, all walls tested may be divided into three groups. Walls of Group 1 were constructed with 2 x 6 in. framing members spaced 16 in. on center with a 2 x 6 in. member at each end of the wall. The inner or warm surface was covered with ⅜ in. gypsum plaster board. This construction was tested without insulation between the framing members and with various thicknesses of insulation applied as described for the various tests within the group.

Walls for Group 2 were constructed without the central framing members, that is with 2 x 6 in. joists only at the extreme edges at the top and bottom of wall, and with ⅜ in. gypsum plaster board on the warm side. This wall was tested with various thicknesses of granular mineral wool hand-applied over the gypsum board in order to get the effect of various thicknesses in insulation without the effect of the framing members.

The wall of Group 3 was of the same construction as those of Group 1, with the exception that 2 x 4 in. framing members were used in place of the 2 x 6 in. framing members of the first group. The framing members were cut to exactly 4 in. in thickness.

Method of Applying Insulation

When granular mineral wool was applied by hand, it was poured into the space between the framing members and levelled off as closely as possible to the required thickness with a strike. The exact thickness was measured by use of a special gage, the various points of which could be adjusted for the exact thickness of insulation. The average thickness for the test was taken as the gage thickness for approximately 60 points over the test area.

In applying the machine-blown mineral wool to the open construction—that is, without flooring, and in a horizontal position—the open end of the blowing hose was held horizontal and about 24 in. above the upper surface of the joists. The space between was filled as closely as possible to the desired thickness, after which it was levelled off with a strike, and the exact thickness measured by the special gage. For the horizontal wall with 4 in. joists in Group 3, the mineral wool was blown level with the joists. For the wall of test 36 with 6 in. joists, the mineral wool was

Table 2—Test Results

Test No.	Date	Air Temperatures, deg. F: Inner Box	Air Temperatures, deg. F: Outer Box	Air Temperatures, deg. F: Outside	Surface Temperature, deg. F: Plaster Board Warm Side	Surface Temperature, deg. F: Plaster Board Cold Side	Surface Temperature, deg. F: Insulation Warm Side	Surface Temperature, deg. F: Insulation Cold Side	Surface Temperature, deg. F: Flooring Cold Side	Overall Coef. *U* as Tested
1	2/11	70.1	71.6	—9.1	42.6	23.2	...	..	..	0.803
26	3/25	70.1	70.8	—9.0	43.6	24.8	...	..	..	0.804
33	4/27	70.3	70.9	—9.2	43.5	24.7	...	..	..	0.843
19	3/10	70.0	70.3	—10.5	66.4	63.7	...	—6.7	..	0.139
2	2/12	70.2	70.3	—10.7	67.4	65.6	...	—8.4	..	0.097
3	2/13	70.1	70.2	—10.3	67.3	65.5	...	—8.2	..	0.105
4	2/15	70.1	70.4	—9.4	67.4	65.2	...	—6.9	..	0.104
12	2/26	70.1	70.4	—10.5	67.6	65.7	...	—7.9	..	0.103
5	2/17	70.0	70.3	—10.6	67.5	65.8	...	—6.1	..	0.101
6	2/18	70.2	70.5	—6.2	67.8	66.1	...	—1.2	..	0.098
35	4/29	70.1	70.3	—10.0	67.8	65.7	...	—6.1	..	0.096
7	2/20	70.1	70.3	+0.1	68.5	67.3	...	+3.3	..	0.081
8	2/22	70.0	70.5	—10.5	68.1	66.7	...	—7.9	..	0.088
10	2/24	70.1	70.7	—10.6	68.1	66.7	...	—8.1	..	0.082
11	2/25	70.1	71.2	—11.4	68.2	67.0	...	—8.1	..	0.080
9	2/23	70.0	70.6	—10.5	68.1	66.8	...	—5.3	..	0.081
14	3/2	70.0	70.3	—10.4	68.0	66.6	...	—8.6	..	0.082
15	3/3	70.0	70.3	—10.3	68.1	66.6	...	—8.4	..	0.082
16	3/5	70.1	70.3	—10.3	68.1	66.7	...	—6.1	..	0.073
17	3/6	70.1	70.6	—9.8	68.2	67.0	...	—6.5	..	0.077
18	3/8	70.1	70.4	—10.3	68.2	66.8	...	—8.6	..	0.080
36	4/30	70.1	70.3	—10.0	68.5	67.0	...	+3.6	—7.3	0.069
34	4/28	70.1	70.3	—10.3	68.0	66.2	...	—7.3	—7.8	0.083
37	5/2	70.3	70.3	—10.2	69.0	68.0	...	—0.7	..	0.059
39	5/4	70.2	70.3	—10.5	68.6	66.1	...	—8.1	..	0.092
21	3/16	70.2	70.3	—10.2	67.4	65.5	63.7	—6.8	..	0.106
22	3/18	70.0	70.5	—10.2	67.6	66.2	63.9	—6.1	..	0.102
27	3/22	70.0	70.2	—10.3	68.0	66.5	63.8	—7.8	..	0.085
28	3/30	70.0	70.2	—10.8	67.9	66.6	63.8	—8.0	..	0.088
20	3/13	70.1	70.3	—10.3	68.1	66.8	...	—7.8	..	0.082
30	4/1	69.9	70.0	—10.2	66.0	62.6	...	—4.3	..	0.136
32	4/26	70.2	70.4	—10.2	67.1	64.5	...	—7.3	..	0.101
46	5/12	70.0	70.2	—10.3	67.5	64.0	...	—5.4	..	0.107
29	3/30	70.0	70.1	—10.2	67.9	66.1	...	—8.1	..	0.075
48	5/13	70.0	70.1	—10.8	68.5	66.7	...	—8.0	..	0.060
38	5/3	70.5	70.3	—10.2	68.5	66.7	...	—6.6	..	0.089

Table 3—Effect of Thickness of Insulation on the Thermal Conductivity k with Heat Flowing Upward

Test No.	Insulation	Actual Thickness of Insulation inches	Overall Coefficient U	Overall Resistance $\frac{1}{U}$	Net Resistance of added Insulation	Conductivity k for added Insulation
1, 26, 33	None	....	1.10	0.909	....	....
30	2-in. Hand Applied Granular Mineral Wool	1.906	0.139	7.194	6.285	0.303
46	3-in. Hand Applied Granular Mineral Wool	2.625	0.107	9.345	8.436	0.311
32	3-in. Hand Applied Granular Mineral Wool	2.940	0.101	9.901	8.992	0.327
29	4-in. Hand Applied Granular Mineral Wool	3.875	0.074	13.514	12.605	0.307
48	6-in. Hand Applied Granular Mineral Wool	5.125	0.060	16.667	15.758	0.325

blown to a thickness of 4 in. after which the floor boards were applied with screws. For the wall of test 37 with 6 in. joists, the floor was in place and the space between the joists was blown full with granulated mineral wool.

For the mineral wool bats in tests 27 and 39 with barriers designated as lapped on the warm side of the joists, the paper flaps along the edges of the bats were lapped over and nailed to the lower faces of the joists underneath the gypsum plaster board. For tests 21 and 22 designated as "barrier laid on warm side," the bat was applied from the cold side of the wall without removing the plaster board, and the flaps were turned upward and pressed in contact with the vertical sides of the joists.

When the walls were tested in a vertical position with loose insulation between the framing members, it was necessary to apply a wire screen over the top of the insulation in order to hold it in place when the wall was put in a vertical position. For tests 5, 6, 10, 11, 16, 17, and 18, a ¼ in. mesh wire covering was fastened between the joists to support the insulation. In order to get true comparative results, the walls were tested with the wire in place both in the horizontal and vertical position.

Discussion of Test Results

A summary of test results is given in Table 1. The temperatures as taken throughout the wall and used for making the calculations are given in Table 2. Referring to Table 1, the walls tested are divided into three groups. The numbers of tests made on each wall of the group are indicated in the third column. When more than one test was made on a given wall, the averages of all of the tests were used for calculating the various coefficients. The fourth column of the table gives the orientation of the wall as tested, and when tested in a horizontal position, the heat was always flowing upward. The thickness and density of the insulation as given in columns 5 and 6, were taken of the insulation as applied in the wall. Thicknesses under the description of test section are the nominal thicknesses and not the actual thicknesses as tested. The thermal conductivity coefficient, k, under the column headed *Test* were calculated from the differences in heat resistance for the insulated and uninsulated walls, from the thickness of insulation applied between the framing members and on the assumption that the insulation covered the full area of the wall. Coefficients under the column headed "Corrected" have been corrected to take into consideration the areas as covered by the insulation only. The overall coefficients U under the ninth and tenth columns are first those calculated from test values from air to air, and second the corrected values based on coefficients for still air on the warm side of the wall and for air at a 15-mile wind velocity on the cold side of the wall.

In determining the test surface coefficients, it was necessary to measure surface temperatures. Although great care was used in measuring the surface temperatures of the exposed surfaces of the insulation, there was still some uncertainty as to what the exact values should be, and since they were used in the calculation of surface coefficients, there may be some slight errors in the corrected value for U. However, these are not great.

Effect of Wall Position on Thermal Conductivity

The comparative results for walls tested with heat flowing upward in a horizontal position and with heat flowing horizontally with the wall in a vertical position are shown by the results of three different walls which were tested both in horizontal and vertical positions. For the first wall, test 5 with the wall in a horizontal position, $U = 0.102$, and for test 6 with the same wall in a vertical position, $U = 0.100$. For the second wall, test 10 with the wall in a horizontal position, $U = 0.081$. For the same wall in a vertical position as in test 11, the U value is the same. For the third wall in a horizontal position, the average of tests 16 and 18, $U = 0.077$. The same result was obtained for test 17 with the wall in a vertical position. Each of these walls had a wire netting applied over the insulation for both tests. These tests indicate that there is no appreciable difference in thermal conductivity for the type of walls tested when placed either in a vertical or in a horizontal position.

Effect of Thickness of Insulation

The effect of the insulation thickness on the thermal conductivity value, k, with heat flowing upward through the insulation, is shown by the results of the tests in Group 2. The results of these tests and the method of obtaining the thermal conductivity value, k, for the insulation have been summarized in Table 3. In making the tests, a wall without framing members over the central section was used. That is, the loose or granulated mineral wool was hand applied to the upper surface of the plaster board over the full test area without joists. It was applied in various thicknesses which were measured by the special test gage provided for the purpose and given in Table 3. All walls were of the same construction with the exception of thickness of insulation applied, and in each case the same type of granular mineral wool was applied. The overall coefficient for the gypsum plaster board only, which represents the wall without insulation, was calculated from test values which were obtained on other test apparatus. However, the calculated value corresponds with the test value for the uninsulated wall with framing members after a correction is made for these members. The calculated value was used in order to obtain from test results the actual resistance of the insulation applied to each of the other walls.

Referring to Table 3, the overall coefficients U are the test values for all but the first wall without insulation. The overall resistances are the reciprocals of these coefficients, and the net resistance due to the insulation represents the difference between the heat resistance of the wall as tested and the resistance of the wall without insulation. The thermal conductivity values k for the insulation in the last column are based on the net resistance and the actual thickness of the insulations as applied. These values are reasonably consistent, considering the fact that it is impossible to make exact determinations of the thickness of the insulation and also that there may be a variation in the size of pellets which make up the insulation. There is no trend toward higher conductivity values per inch of thickness as the thicknesses increase.

Effect of Studs on the Apparent Value of Insulation

From the test results for walls with and without studs, the differences in the overall value for the walls become greater as the thickness of insulation is increased. If curves are plotted, it will be found that the overall coefficients are substantially the same for 2 in. of insulation either with or without studs. For 4 in. of insulation the average U values from the curves are 0.072 for the wall with-

out studs and 0.084 for the wall with studs. This indicates the differences or errors that might be made by assuming the insulating material to cover the full area of the wall and not corrected for the framing members.

Effect of Paper Covering Over Surfaces of Insulation

A comparison of the results for test 9 and the averages for tests 7 and 8 shows the effect of laying a heavy kraft paper over the top and in contact with the insulating material. With the paper in contact with 4 in. of insulation between the studs, the overall coefficient is 0.083, whereas without the paper it was 0.084. The paper was laid over the insulation in contact with the surface, and fitted closely between the joists.

Comparison of Values for Hand-Applied and Machine-Blown Insulation

For test 7 and test 8, 4.05 in. of granular insulation placed between the studs gave an overall coefficient of 0.084. For tests 14 and 15, 4.04 in. of granular insulation machine-blown between the studs gave an overall coefficient of 0.081. For test 34, 4.14 in. of loose wool insulation blown between the studs gave an overall coefficient of 0.083. In all of these tests, the densities were from 6.3 to 6.6, and the results were substantially the same. For test 35, however, 3.21 in. of granular rock wool blown between the joists gave an overall coefficient of 0.087. In this case, the apparent insulating value of the material is better than it was in either of the other cases. However, in this case the density is 5.90, which may explain the difference. In general, it appears that for the same type of material, the results for the hand-applied material will be substantially the same as those for the machine-blown material.

All the walls except those for tests 36 and 37 were tested without attic flooring. For test 36, 3.87 in. of blown granular mineral wool was covered with 1 in. flooring. This wall, tested in a horizontal position, gave an overall coefficient of 0.069 which corresponds almost exactly with the calculated value when correcting for the studs. Comparing this value with figures given in the Heating Ventilating Air Conditioning Guide 1943, the closest construction for a ceiling is one consisting of metal lath and plaster, 3⅝ in. rock wool fill insulation, and yellow pine flooring on joists. The coefficient U given for this construction is 0.068. Thus, there is no substantial difference between the test value and that used in The Guide.

Discussion

R. S. Dill, Washington, D. C. (Written): I do not attach as much importance to the orientation of the wall as the authors appear to for the reason that if convection occurs in the wall when the wall is in a horizontal position, convection will also occur in the wall when it is in a vertical position, although admittedly the amount of the convection may not be the same for the two cases. Since insulation is not ordinarily left uncovered when installed in vertical walls, the significance of the observations on materials in this position decreases further in my opinion.

I am in agreement with Professor Rowley that the preponderance of the data and information which has come to hand so far indicates that the effect of convection currents in horizontal layers or blankets of insulation is practically insignificant and furthermore that in computing the heat transfer through walls, the effect of timbers in the form of joists or other house elements which extend through the insulating layer should be taken into account.

In their paper the authors use this sentence: "One method is to assume a thickness equal to that of the insulation, and another is to use the full thickness of the framing members." By thickness is meant that dimension, of a framing member, parallel to the heat flow.

In my opinion, use of the full thickness of the framing members is not justified if such members project very much above the insulating material. On the other hand, if the members do project above the insulating material, their insulating effect may be slightly under-estimated if their thickness is assumed to be exactly equal to that of the insulating material. In the present state of knowledge, I would favor an assumption of a thickness ¼ in. greater than that of the insulating material for purposes of computation when the members project more than ¼ in. above the insulating material.

Neither of the above methods of computation or any other approximation is absolutely accurate. There are lateral gradients to the heat flow through a combination of wooden members and insulating material such as that under consideration here, which prevent the computations from being in the class of absolute accuracy. Such computations, however, are considered to be sufficiently accurate for their purpose.

The data obtained by Professor Rowley and his co-author, as well as the results of some less formal tests made here, indicate strongly that the convection effect does not require consideration for practical purposes. However, as long as the opposition view has the backing of Prof. G. B. Wilkes, Massachusetts Institute of Technology, perhaps some work on the subject should continue until the matter is brought to a conclusion satisfactory to all concerned; but in the meantime my recommendation is that convection be ignored so far as estimates of heat losses from buildings are concerned.

T. T. Tucker, Atlanta, Ga. (Written): The stones which compose the foundation of our Society are the technical data which we publish for the benefit of mankind. The mortar which cements these stones together is the fact that these technical data work. This paper is another proof of the practicality of our Society. It is a *refresher* course, so to speak, which we have passed.

But this paper goes further than that, it shows conclusively where many laymen have erred in trying to add things to insulation in the hopes of improving its effectiveness. For example, we see now what every one should have known all the time. Insulation properties do not change with position. Also, there is no difference in the practical results obtained from factory fabricated bats, mechanically applied materials, and hand packed granules. Contrary to the opinion of many architects and federal specification writers the paper backing on mineral wool has no bearing on its efficiency; regardless of how the paper is installed. The authors have by this splendid paper shown that the only thing which will improve good insulation is more insulation.

The authors have shown too that there is really no need for us to bog down in our own technical data. They have recognized the difficulty of determining the exact thicknesses of mineral wool. They have recognized too that things about which the ultimate user seldom bothers himself such as fiber diameter, pellet size and installed density do affect thermal conductivity. I quote "for practical purposes, average values must be used in calculating coefficients."

Perhaps the authors should answer these questions: Was the machine blown mineral wool applied in accordance with usual practice in the field and by some one experienced in that art? If so, how do they account for the density of this wool being so much greater than the factory fabricated bats which they tested?

L. R. Vianey,[1] Cambridge, Mass. (Written): I am pleased to be able to be here to comment on the work presented by Professor Rowley.

There are several points which I would like to bring up for discussion and clarification.

Our experience at M.I.T. indicates that heat transfer measuring equipment with an on and off power input does not give as satisfactory equilibrium conditions as can be obtained with constant input type of apparatus. If I am not mistaken the guarded plate "standards" call for a constant input to the central section and a differential thermocouple control of the guard ring. I believe that this should also be applied to the guarded box test thus eliminating the relatively large temperature differentials required to operate thermostatic controls.

Another point in the authors' equipment is the apparent lack of separating partitions between the insulation comprising the test area and that in the guard area. It has been our experience and also that of Professor Queer of Pennsylvania State College that such partitions prevent heat transfer between the guard and test areas by convection through the insulating medium or enclosed air spaces. These separators should in my opinion be incorporated into a test of the sort reported by Professor Rowley.

Furthermore there is some doubt in my mind as to whether or not sufficient time has been allowed after a change in test conditions for the equipment and insulating material to reach thermal equilibrium.

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[1]Instructor in Mechanical Engineering, Massachusetts Institute of Technology.

Since the air temperature in Professor Rowley's equipment was controlled by thermostats, I presume that the heaters and cooling units had sufficient capacity to bring the surrounding air to the required temperature rapidly. Since surface temperatures will quickly follow a change in air temperature, they also will be rapidly brought up to and maintained at the temperatures fixed and controlled by the thermostats. Therefore, apparently constant temperature gradients will be attained in a very short time while thermal equilibrium in the insulating material will not be reached for a considerable time after the surface temperatures are constant. Thus if changes in test conditions are made and readings are taken too soon thereafter, true steady state conditions will not exist and the resulting test values will be erroneous.

I would like to quote some recent work performed at M.I.T. to substantiate my previous statements. The following data was obtained with apparatus similar to Professor Rowley's except that our input to the test area was constant and that to the guard area was controlled by a multiple differential thermocouple and photoelectric relay arrangement. The actual operating temperatures were different.

Data from Tests at M.I.T.

Date		U[a]	Air Temps deg F Inside	Outside
5/18		Installed	3 in. mineral wool 5 lb per ft³—no joists	
5/19		0.126	...	...
5/20		0.120	139	75
5/21		0.120	139	75
5/21	1 P.M.	Laid 1 layer paper over entire surface		
5/22		0.117	141	75
5/23		...	...	...
5/24		0.113	144	77
5/25		0.110	145	76
5/26		0.110	145	75

[a]U = Btu, hr, -¹ ft, -² deg F-¹ Average of hourly calculations.

These results show in my opinion that even for the minor change which was made in the above test a very considerable time is required to reach true equilibrium conditions. In comparison I would like to point out a set of results taken from Professor Rowley's paper. I quote:

Test No.	Date	Type of Test
32	4/26	3 in. hand applied wool—no joists
33	4/27	No insulation
34	4/28	4 in. machine applied wool
35	4/29	3 in. machine applied wool
36	4/30	4 in. machine applied wool with 1 in. floor
...	5/1	No test recorded
37	5/2	6 in. machine applied wool with 1 in. floor
38	5/3	4 in. machine applied wool with 2x4 joists
39	5/4	3 in. mineral wool bats

It is my opinion that if tests are conducted as rapidly as indicated, we cannot be sure that true thermal equilibrium exists, and therefore if we are not sure of steady state conditions, we cannot be sure of the resulting coefficients.

G. L. Tuve, Cleveland, Ohio, expressed his confidence in the accuracy of tests reported by Professor Rowley. He pointed out that insulation must be properly applied if the results are to be the same as calculated from ASHVE Guide data. The possibility of difference between the heat transmission of a complete wall as compared with a test panel was mentioned. The presence of moisture in the insulation (as affected by the time of year and test temperatures) was suggested as a factor which might produce variance in results of different investigators.

R. K. Thulman, Washington, D. C., emphasized the importance of determining the correct heat transmission data especially for ceilings in order to prevent confusion and disappointment in the minds of the public which would purchase insulation. Since within six months two papers by eminent investigators had reported widely varying results and since these results varied from figures (taken from ASHVE Guide) shown in FHA publications, it was important that the Society establish the correct figures which should be used.

Professor Rowley closed the discussion, explaining that standard applicators with standard blowing equipment had been used for machine blown insulation and that he had observed the work.

The density of average mineral wool as now manufactured is less than The Guide value and there is a range of densities available. The conductivity values are substantially the same as given in The Guide. Density is not the determining factor in conductivity which depends on fiber size and the pack of the fibers. Heavy fibers might weigh a lot and yet be very porous. Light material may test better than a heavier one or vice-versa. Continuous and on-and-off controls had been found to give the same results when the controls operated properly.

In answer to Mr. Vianey's comment that the tests might not have been conducted under equilibrium conditions Professor Rowley explained that all tests were conducted at equilibrium conditions held for 6 to 8 hours. Many of the tests were repeated with same results as reported. When the same walls were tested for more than one day there was no shut down occurred between tests. The effect of separators had been found by test to be negligible. The accuracy of the test methods employed had been proved by the ability to test-check day after day.

Professor Rowley felt that the effect of moisture would not be important in mineral wool because it is not hygroscopic. Even in hygroscopic material such as wood fiber material moisture would not be expected to materially affect test results. It would have no effect in comparative tests of two wall positions.

Test results were found to agree almost exactly with Guide figures for overall values for similar walls. The Guide values therefore appear to be accurate, practical and perfectly logical for use.

NOMINATIONS INVITED

The Committee of Award for the F. Paul Anderson Medal will receive nominations until August 1, 1943.

The F. Paul Anderson Medal is awarded to a member of the ASHVE, "in recognition of notable scientific achievement or for outstanding service performed in the field of heating, ventilating or air conditioning."

Nominations should be addressed to the Committee of Award for the F. Paul Anderson Medal and should be accompanied by a detailed statement indicating the specific achievement or service performed.

The committee shall carefully consider nominations for a period of not less than three months and will submit its recommendations to the Council at the final Council Meeting of the calendar year.

Under the regulations the Council has the power to decline to make any award for any year.

The undersigned Committee of Award of the F. Paul Anderson Medal invites members of the Society to submit nominations.

S. H. Downs, *Chairman*

Tom Brown

F. E. Giesecke

L. L. Lewis

F. B. Rowley

The Economic Factors in Converting Recirculated Air for Ventilation

By Herbert E. Ziel,* Detroit, Mich., and Henry Sleik,† New York, N. Y.

SUMMARY—**Ventilation may be divided into the air required, on the one hand, to support physiological processes and, on the other hand, to dilute internally generated or accumulated air entrained impurities. The former is so small a percentage of the total that, in all but hermetically sealed enclosures, it will be obtained through unavoidable infiltration. It is desirable in the interest of economy, therefore, to substitute already conditioned room air for that portion of the ventilation (over and above the new air required solely to counteract infiltration effect) provided such air is effectively purified. It has been demonstrated in actual practice that properly applied activated carbon gas adsorption supplemented by adequate filtration of particulate substance and, where warranted, bacteria control, will requalify vitiated room air for re-use as a ventilation medium. And as such air reclamation is decidedly less costly both in equipment and operation than the conditioning of an equivalent volume of replacement air, serious consideration of its application is recommended.**

THIS PAPER is confined to a consideration of the practicability of treating return air so as to qualify such air for use as a dilution medium in lieu of new outside air and thereby effect a saving in primary conditioning equipment, fuel and energy. It does not, therefore, undertake to substantiate the minimum physiological requirements or limits assumed in its development beyond insuring that these have the credence of published authority.

Ventilation Essentially Dilution

It has been long recognized that a preponderance of the total volume of new air required for ventilation is needed solely to dilute internally generated and accumulating air pollution and that the remainder required to maintain adequate oxygen concentration is so small as to be negligible in comparison.[1] In view of the inconclusive or negative results of much recent investigation concerning the effect of ionic changes, condensation-nuclei, CO_2 concentration indices and other purely chemical reactions,[2] it is still reasonable to assume that aside from its oxygen content, the quality of air freshness is essentially a function of its degree of freedom from foreign impurities.

The principal sources of these impurities in enclosures of residence, assembly and commercial activity are the occupants and their habits—body, apparel and respiratory emanations, tobacco smoke, cosmetics and, where dispensed, liquor and edibles and their cooking or preparation. In the average industrial establishment of a general manufacturing nature, that is, not devoted to chemical processes or operations which may contribute distinct fume pollutions, there are added contaminating sources such as, particularly, cutting and lubricating oils and greases, hydrocarbons, acidic and metallic oxides, internally generated dust, soot and, occasionally, smoke. In all instances, the aggregate air contamination is in part particulate and in part gaseous. The elimination of the former from return air before it is recirculated is already accomplished by the use of efficient air filters supplemented, where necessary, by electrostatic precipitation. The control of bacteria, when a problem, is within the scope of the sterilamp. It remains, therefore, only to extract the polluting gaseous components in order to fully requalify such return air to assume the burden of dilution and thereby permit the volume of new air required to be limited to the function of oxygen replenishment and exfiltration or exhaust replacement.

Control of Gaseous Contaminants by Adsorption

Active gas adsorbent carbon, produced from nut shells, specially activated by the gaseous oxidation method and processed to a critical apparent density of about 0.45 (for 6 to 14 mesh granules) and a 66 per cent granule porosity, has been found to effectively adsorb and retain most of the foreign organic gaseous substances common to vitiated air at ordinary ventilating temperatures.[3] (For convenience in reference, *organic* is used in this connection to represent all adsorbed substance independent of water, whether such substance is organic or inorganic in the chemical sense.) The more notable exceptions are CO, CO_2 and ammonia. While these latter are adsorbable in some degree, experience has indicated that the adsorption efficiency of the carbon for these substances at ordinary temperatures is too low to promise a useful contribution. Nor does activated gas adsorbent carbon exhibit like retentivity for all gaseous substances, this being influenced to a great extent by the nature, boiling points and vapor pressures of the organics involved. However, the quality carbon under consideration and which is similar in structure and specification to that employed in military poison gas masks has an activity or adsorptive capacity ranging up to 70 per cent of its own weight of organic substance. Further, almost all of the common gaseous contaminations encountered in occupied areas, particularly body excretions, putrefaction gases, acrolein, hydrocarbons, mercaptans, essential oil and flavor essences, sulphurous gases and the like are all highly adsorbable. While, therefore, there are many variable factors, the *over-all average* adsorption efficiency of this carbon when employed to treat recirculated air in the manner to be explained, has been found to be not less than 95 per cent up to the point where the carbon's saturation does not exceed 15 per cent by weight, independent of moisture. Also, with the low concentration encountered, a saturation of 15 per cent has been observed to represent an exposure of from six months to two years depending upon the nature and condition of service. Furthermore, the carbon when saturated

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†Vice-President, W. B. Connor Engineering Corp.

[1] *a.* Heating Ventilating Air Conditioning Guide, 1943, Chapter 2, Physiological Principles.

b. Modern Air Conditioning, Heating and Ventilating, by W. H. Carrier, R. E. Cherne and W. A. Grant, pp. 7, 19, 20.

[2] ASHVE Research Report No. 921—Changes in Ionic Content of Air in Occupied Rooms Ventilated by Natural and Mechanical Methods, by C. P. Yaglou, L. C. Benjamin and S. P. Choate. (ASHVE Transactions, Vol. 38, 1932, p. 191.)

ASHVE Research Report No. 965—Physiologic Changes During Exposure to Ionized Air, by C. P. Yaglou, A. D. Brandt and L. C. Benjamin. (ASHVE Transactions, Vol. 39, 1933, p. 357.)

ASHVE Research Report No. 985—Diurnal and Seasonal Variations in the Small Ion Content of Outdoor and Indoor Air, by C. P. Yaglou and L. C. Benjamin. (ASHVE Transactions, Vol. 40, 1934, p. 291.)

The Nature of Ions in Air and Their Possible Physiological Effects, by L. B. Loeb. (ASHVE Transactions, Vol. 41, 1935, p. 101.)

The Influence of Ionized Air upon Normal Subjects, by L. P. Herrington. (Journal Clinical Investigation, 14, January, 1935.)

People and Atmospheric Ions, by Dr. G. R. Wait. (Carnegie Institution of Washington News Service Bulletin, Vol. IV, No. 28, June 12, 1938.)

Presented at the Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers, Pittsburgh, Pa., June, 1943.

[3] Industrial and Engineering Chemistry, Vol. 15, No. 12, p. 1244. Heating Ventilating Air Conditioning Guide, 1943, Chapter 29, Air Cleaning Devices, p. 573. Loc. Cit. See Note 1 *b*, p. 220.

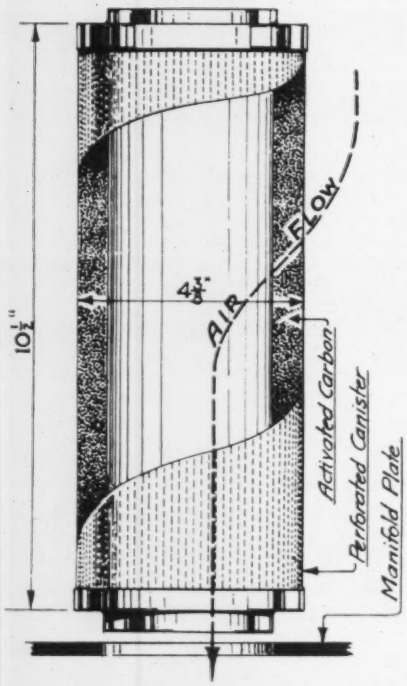


Fig. 1—Typical carbon canister

can be repeatedly reactivated for reuse.

Activated gas adsorbent shell carbon has been demonstrated in practice to possess all of the properties favorable to its practical use in ventilation—hardness and durability, freedom from dust, high adsorptive capacity and retentivity for most air-borne gaseous impurities, selectivity for these organic substances in preference to moisture (activated carbon rejects water for organics) and capability of repeated reactivation. Moreover, it has the advantage over all other attacks upon gaseous air contaminants in that it apparently neither adds anything to the air nor alters either its ionic or chemical composition or its thermal and psychrometric state.

Adsorption Equipment and Its Application

The practical application of activated carbon filtration equipment to the air conditioning system has likewise been developed. The accompanying illustrations are sufficiently self-explanatory to require little elaboration. Summarized, the application consists of the means of suspending in the air stream the requisite quantity of carbon per unit of air to be treated without exceeding a practicably allowable resistance to the air flow, yet within a reasonably compact space; and to provide facility for the easy exchange of the carbon periodically for reactivation with a minimum of interruption in service. Fig. 1 shows a typical, perforated, granular carbon filled, hollow canister, while Fig. 2 shows a typical assembly of the canisters. The arrangement is such that all air to be treated must pass uniformly through the carbon beds, thereby being subjected to uniform duration of contact with the adsorption media. In ordinary applications, the air velocity through the carbon beds is approximately 35 fpm and, as a consequence of the serried development of the beds, the air approach velocity to the assembled unit is about 250 fpm. Thus, the face area of the assembled treatment unit approximates that of the average air filter and the depth (in direction of air flow) about 4 ft. The resistance to air flow is 0.15 in. of water.

In considering the practicability of qualifying return air for use as ventilation, it is emphasized again that this applies to dilution ventilation only, independent of oxygen make-up. It is, therefore, necessary to segregate the two demands. In other words the total ventilation, as determined by the designing engineer for the particular application, based upon his individual experience or conviction, need not be disturbed. Instead, however, of satisfying this total ventilation entirely with outside air, that portion of the total ventilation required alone for the dilution of contaminants, *i.e.*, to control the concentration of internally generated impurities, can be obtained by the use of decontaminated return air added to recirculation and, therefore, be deducted from what would otherwise be the required outside air volume. It remains, then, to determine what should be considered the safe minimum of outside air volume required solely for oxygen replenishment, and CO_2 concentration control if preferred.

It has been advanced that 1 cfm of new air per person will provide ample oxygen for an active worker and that 3½ cfm per person will prevent the CO_2 concentration from rising above 1 per cent, a limit generally regarded as providing an ample factor of safety.[4] The authors believe that, pending further research, a minimum of 5 cfm of new outside air per occupant will preclude any enervating effect. This conclusion is based upon the result of dilution computations.

An average sedentary adult will consume roughly 0.8 cu ft of oxygen per hour and produce approximately the same amount of CO_2. When physically active, the average adult's oxygen consumption and corresponding CO_2 generation may increase to about 1.2 cu ft per hour. Arbitrarily adding a further liberal insurance factor by raising the latter figure to 1.5, the resulting concentration in an occupied enclosure, at equilibrium, when introducing 5 cfm, or 300 cfh of new air per occupant, will be:

For oxygen (orginal concentration 21 per cent)

$$\frac{\left(\frac{300 \times 21}{100} - 1.5\right) \times 100}{300} = 20.5\%$$

For CO_2 (original concentration 0.04 per cent)

$$\frac{\left(\frac{300 \times 0.04}{100} + 1.5\right) \times 100}{300} = 0.54\%$$

It will be noted that the indicated resultant oxygen concentration of 20.5 per cent corresponds to the amount of oxygen prevailing outdoors at an altitude of only about 700 ft above sea level. The resultant CO_2 concentration is but ½ what is considered, so far as the authors can ascertain, indubitably harmless. And if, further, the assumed physiologically adequate 5 cfm of new air per occupant is supplemented by an adequate volume of uncontaminated dilution air, complete psychological comfort will be provided.

It is doubtful also, whether, in common ventilation practice it will often be advantageous to consider a reduction in outside air supply to less than 5 cfm per occupant because, in all but hermetically sealed enclosures, the normal infiltration, or the outside

[4] "Your Place in the Smart Man's War, by George W. Meek. (Heating, Piping & Air Conditioning, August, 1942.)

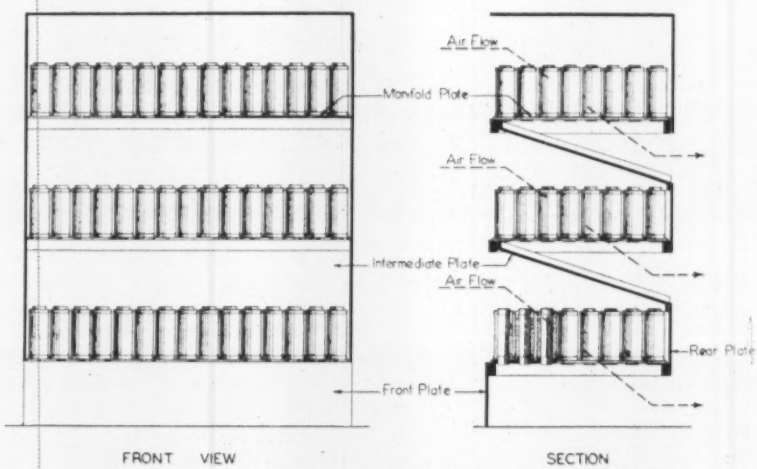


Fig. 2—Arrangement of activated carbon canisters

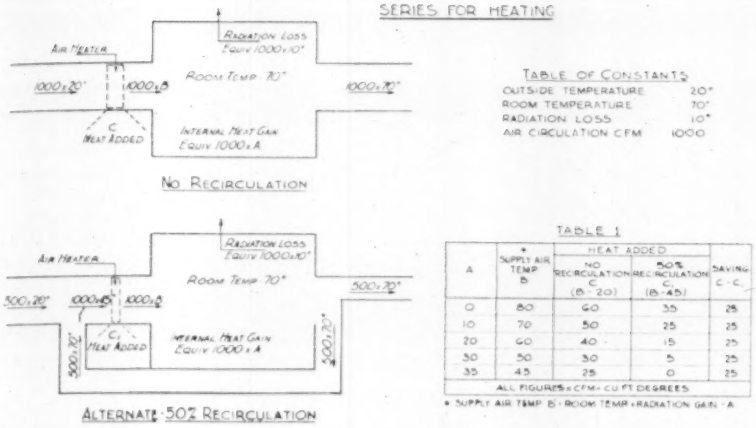


TABLE 1

A	* SUPPLY AIR TEMP B	HEAT ADDED NO RECIRCULATION C (B-20)	HEAT ADDED 50% RECIRCULATION C (B-45)	SAVING C-C,
0	80	60	35	25
10	70	50	25	25
20	60	40	15	25
30	50	30	5	25
35	45	25	0	25

ALL FIGURES x CFM - CU FT DEGREES

* SUPPLY AIR TEMP B = ROOM TEMP + RADIATION GAIN - A

Fig. 3—Diagram and table showing outside air heating load calculations

air volume introduced mechanically to counteract infiltration effect, will usually exceed the maximum demanded to maintain a safe oxygen and CO_2 concentration.[5] The infiltration factor will, therefore ordinarily provide the simplest criteria for the establishment of the new air component. An example will make the foregoing clear as well as illustrate the modified approach to a typical ventilation problem recommended by this paper.

Assume a building with a volume of 500,000 cu ft and an occupancy of 1250 and requiring an air conditioning system having a total circulating capacity of 100,000 cfm (12 turnovers per hour). Further, that the nature and activity of the occupants is such that 25,000 cfm or 20 cfm per person (3 air changes per hour) is the correct *ventilation* necessary to maintain satisfactory internal air quality. In line with the previous conclusions, the outside or new air may be reduced to 6250 cfm (5 cfm per occupant). In the instance under consideration, however, it is conceivable that the infiltration factor may be one air change per hour or 8,333 cfm, equivalent to 6.67 cfm per occupant.

In order, then, to take advantage of the outside air reduction permitted physiologically or dictated by building filtration and yet maintain both the stipulated total air circulation of 100,000 cfm and the required ventilation of 25,000 cfm, the indicated modification would be as follows: 100,000 cfm total air, 8333 cfm outside air and 91,667 cfm recirculated air *of which latter* 16,667 cfm (25000-8333) is decontaminated.[6] Since, however, it has been found that the over-all efficiency of the carbon decontaminating medium to be employed is 95 per cent (this will apply approximately, likewise, for dust filters and bacteria control, if used), it is merely necessary to compensate by treating $\frac{16,667}{0.95}$ or 17,545 cfm of the recirculated air. This, incidentally, is a factor meriting emphasis. Since the process is one of dilution, its efficiency is capable of control by compensation. A device capable of extracting 95 per cent of the entrained contaminants from a given volume of air may be said to provide uncontaminated air equivalent to 95 per cent of the volume treated. Should, therefore, further experience warrant a revision of the present 95 per cent over-all efficiency, it would modify only the *ratio* of air to be treated.

Segregation of Outside Air Load

In calculating the economic effect contributed by the substitution of qualified return air for outside air ventilation, it is simply necessary to segregate the outside air load, a method of computation already used by many designers in preference to the calculation of air mixtures. In fact, it can be demonstrated that regardless of the method adopted, the outside air supply is a distinct and unrelated conditioning load and, therefore, a calculable entity in the summation of the equipment capacity and energy required by the conditioning system. For instance, assume the building already used in the previous example to be located in the average temperate zone with an outside design condition of 0 F for the heating season and 76 deg wet-bulb for the cooling season and that the inside requirements are 70 F dry-bulb and 40 per cent relative humidity (56 deg wet-bulb) for winter and 67 deg wet-bulb for summer; the saving in installed conditioning equipment capacity for a reduction of 16,667 cfm in outside air will then be:

$\frac{16,667 \times 60 \times 23}{14} = 1,643,000$ Btu per hour installed heating capacity.

$\frac{16,667 \times 60 \times 7}{13.3 \times 12,000} = 43.9$ tons of installed refrigeration.

The 23 and 7 Btu per pound of air differential, respectively, between inside and outside conditions used in the foregoing equations are approximate and will vary insignificantly depending upon the particular psychrometric table used.

The respective operating savings in cooling energy and fuel may likewise be computed for the average mean climatic conditions. Assuming a heating season of 5,000 degree-days and an average outside temperature of 40 deg or $\frac{5000}{(65-40)} = 200$ average heating days with 70 per cent over-all heating efficiency and 24 hours per day heating, the saving in British thermal units per heating season will be:

$$\frac{16,667 \times 60 \times 24 \times 200 \times 10.8}{14 \times 0.70}$$

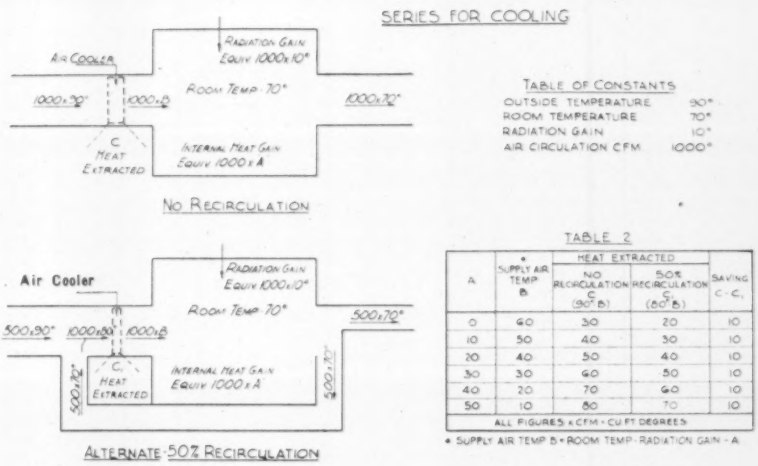


TABLE 2

A	* SUPPLY AIR TEMP B	HEAT EXTRACTED NO RECIRCULATION C (90°-B)	HEAT EXTRACTED 50% RECIRCULATION C (80°-B)	SAVING C-C,
0	90	30	20	10
10	80	40	30	10
20	70	50	40	10
30	60	60	50	10
40	50	70	60	10
50	40	80	70	10

ALL FIGURES x CFM - CU FT DEGREES

* SUPPLY AIR TEMP B = ROOM TEMP - RADIATION GAIN + A

Fig. 4—Diagram and table showing outside air cooling load calculations

[5] Heating Ventilating Air Conditioning Guide, 1943, Chapter 2, Physiological Principles.

[6] The ratio of 1:2 between outside and decontaminated return air in this example is purely accidental. The ratio is not fixed but is dictated entirely by the known or anticipated occupancy, other contributory internal contaminants, infiltration effect, unreclaimable exhausts, etc., incidental to the particular application.

Converted into fuel oil at 145,000 Btu per gallon, this represents a saving of 36,500 gal per heating season. For coal at 14,000 Btu per lb, it means a conservation of approximately 190 tons per season. Similarly assuming a cooling season of 1500 operating hours, an average cooling load of 60 per cent of design load and 0.75 kw hours input per ton of refrigeration, the saving in energy is:

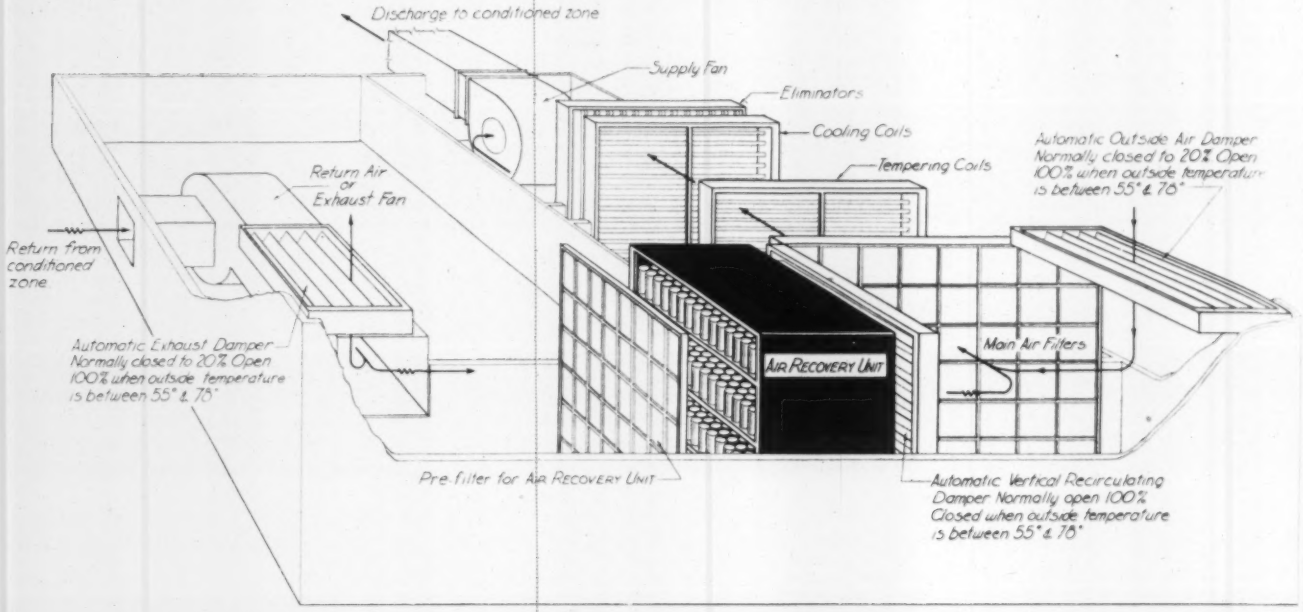
$$\frac{16{,}667 \times 60 \times 1500 \times 7 \times 0.6 \times 0.75}{13.3 \times 12{,}600}$$

or approximately 29,000 kw hours per cooling season.

By segregating the outside air load it becomes apparent that except in abnormal cases, this load is uninfluenced by the internal heat load because all outside air introduced must be converted from prevailing outdoor to prevailing indoor conditions. This is simply illustrated by the diagram (Fig. 3) representing a space conditioned with 1,000 cfm all outside air and, alternatively, with 500 cfm outside and 500 cfm recirculated air. For convenience, calculations are in arbitrary cubic foot-degrees and the constants adopted are 20 F outside, 70 F inside and a room radiation loss equivalent to 10,000 cubic foot-degrees. With no internal heat gain, the heat added (c) for all outside air supply is 1000 x (80-20) = 60,000. By recirculating 500 cfm the heat added (c_1) becomes 35,000, a reduction of 25,000. With an internal heat gain equivalent to 10,000 the heat added for all outside air is 1000 x (70-20) = 50,000 and with 500 cfm recirculated it becomes 25,000, a reduction again of 25,000.

Table 1 continues the series for varying internal heat gains. It will be observed that, up to the point where the internal heat gain is so great that economy ceases to be a factor, the saving in both heating equipment and fuel for a reduction of 500 cfm in outside air is a constant of 25,000 cubic foot-degrees regardless of the internal heat gain and that this constant is equivalent to the heat required to convert 500 cfm from 20 deg outside to 70 deg inside temperature.

The same applies, likewise, to cooling (Fig. 4). By assuming 90 deg outside, 70 deg inside and 10,000 cubic foot-degrees equivalent room ra-


Discharge to conditioned zone
Supply Fan
Eliminators
Cooling Coils
Tempering Coils
Automatic Outside Air Damper Normally closed to 20% Open 100% when outside temperature is between 55° & 78°
Return Air or Exhaust Fan
Return from conditioned zone
Automatic Exhaust Damper Normally closed to 20% Open 100% when outside temperature is between 55° & 78°
AIR RECOVERY UNIT
Main Air Filters
Pre-filter for AIR RECOVERY UNIT
Automatic Vertical Recirculating Damper Normally open 100% Closed when outside temperature is between 55° & 78°

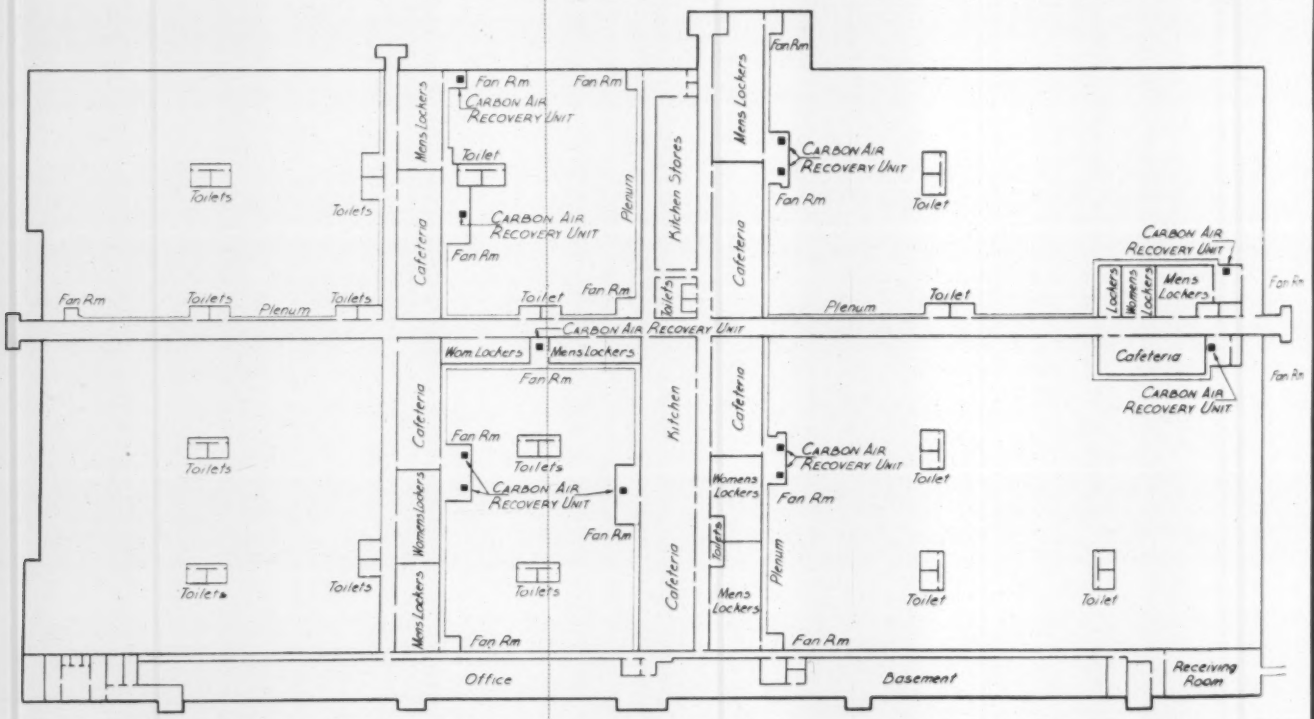


Fig. 5—Basement plan showing distribution of fan rooms and typical fan room showing relation of air recovery unit

diation gain, the saving in recirculating 500 of 1,000 cfm total air is 500 x (90-70) = 10,000 cubic foot-degrees regardless of internal heat gain except that, in this instance, the series (Table 2) is infinite, it being assumed that there would be no internal cooling influence.

Application in Practice

The authors, through their respective experiences, have been afforded several opportunities of applying in practice the principles to which this paper is devoted, and it is deemed adequate to append a factual review of but one of these applications.

In designing the air conditioning system for a mid-west plant of the Pratt and Whitney United Aircraft Corp., it was determined that the requisite ventilation for the cafeteria, locker rooms, toilets and similar areas ordinarily demanding a high air change rate would be 458,000 cfm. Also that, due to design conditions, over half the air displacement would have to be in summer cooled as well as winter heated zones while the remainder would be in winter heated zones only. The design conditions were, Winter —10 deg outside, average for October 1 to May 1, 44.3 deg; Summer 100 deg dry-bulb, 76 deg wet-bulb, average load 60 per cent.

Through the aid of activated carbon adsorption, it was found possible to divide this ventilation requirement into 77,000 cfm outside air, sufficient to counteract infiltration effect, and 381,000 cfm of decontaminated return air added to recirculation. Thus the indicated dilution ventilation and total air circulation was maintained but the outside air load was reduced by 80 per cent. Further, as the primary purpose of the carbon application was to reduce the outside air conditioning load, it was only necessary for it to be in operation during such periods when the outside temperature rose above 78 deg or fell below 55 F. By designing the method of control accordingly, full advantage could thus be taken of outside air ventilation when it imposed little or no demand on cooling or heating energy and, at the same time, conserve the service life and, therefore, the maintenance of the air purification equipment.

Fig. 5 shows the basement plan of this plant and the distribution of 12 main fan rooms; also an enlarged typical schematic arrangement and air-flow diagram of one of these fan rooms. The typical arrangement clearly illustrates the relation of the air recovery unit to the air circulating system as well as the function of the automatic dampers to maintain, on the one hand, a minimum conditioning load and, on the other, a maximum carbon service life between reactivations. In addition to the 12 units shown on the plan there are 27 smaller systems, mostly in toilets where, instead of being exhausted, the toilet air is decontaminated and returned to the plant areas, thereby maintaining the desired differential pressure.

The recovery of 381,000 cfm conditioned air effected a saving of approximately 800 tons of installed refrigeration and 33,000,000 Btu per hour capacity of installed heating apparatus. The estimated operating saving per average heating season is 53,000,000 lb of steam or, approximately 500,000 gal of fuel oil. The economy in summer cooling energy, which would approximate 450,000 kwhr per season is, in this instance, likewise realized in fuel economy since the refrigeration compressors at this plant are steam turbine driven.

Economic Factors

Both the cost to reclaim vitiated conditioned air for ventilating use and the alternate cost to condition replacement air are too variable to permit precise comparison in this paper. Careful analysis indicates, however, that the installed cost of equipment to effectively decontaminate return air rarely approaches the installed cost of the additional refrigeration alone required to cool an equivalent volume of new air. And with heating apparatus costs added, the use of outside air for dilution ventilation is obviously at a decided economic disadvantage. This seems true likewise of operation, the maintenance of decontaminating equipment being appreciably less costly than the fuel and energy its use conserves.

Conclusion

1. Aside, therefore, from its important immediate contribution to the conservation of critical materials and vital resources in our present emergency, the art of reclaiming conditioned air through purification for use in lieu of new air for ventilation warrants serious consideration, both for its efficacy and practicability and for its fundamental economy.

2. The need of research to establish proper air quality and air quantity for comfort and health standards is recognized by the authors as well within the functions of the Society.

Discussion

G. Donald Fife, Washington, D. C. (Written): In the majority of comfort cooling installations, the amount of outside air used would seldom be as high as both 20 cfm per person and 3 changes per hour.

One of the first questions that comes to mind is that of the reactions of the occupants in spaces conditioned by such a system. Have any complaint records been kept? Has any poll of the occupants been taken which would indicate general satisfaction with the ventilation? It would be very interesting to have a description of an air conditioning system which has been remodeled for using decontaminated air, together with an analysis of the occupants' reactions along the lines of some of the polls which have been taken for sensations of comfort.

This is a thought-provoking paper in that there are such well recognized possibilities of savings in both first costs and operating costs attendant to any scheme which will permit a reduction of the outside air quantity.

R. W. Keeton,[7] M.D., Chicago, Ill. (Written): Expired air often contains volatile substances which are obnoxious. Similar odors arise from various glands of the skin in periods of sweating. It is obvious that a wide variety of other odors, vapors, and bacteria originating within the enclosure might contaminate the air. Special filters, adsorbing agents, and devices for sterilizing the air will be required to rid it of these foreign impurities.

We have recently been exposing subjects for eight hours to sub zero temperatures in a small room in which practically all of the air is recirculated. The only outdoor air which is obtained for the support of the physiological processes is by infiltration or leakage. The human load was heavy, but despite this the carbon dioxide concentration reached only 0.46 per cent after the end of three hours. In a short time after the room was vacated the concentration dropped to 0.04 per cent. Since there was no sweating, there were no obnoxious odors from the skin. Those present in the expired air were not noticeable.

I would feel that the proposed plan is physiologically sound and might become practical when the studies on the effective purification of the air have been completed.

L. L. Lewis, Syracuse, N. Y. (Written): The development of means and methods of applying adsorbent substances for the purification of air has quite a few years of experience behind it and has gone through much of the inevitable grief.

The equipment in question was first looked upon as a means of abating nuisance odors. The need for that application will continue to exist but the broad objective toward which it is now being pointed is a reduction of the owning and operating costs of air conditioning and heating systems.

That objective is good for it will enlarge the scope of application and stimulate the application of the wide variety of equipment in which we are interested. If overall costs can be reduced, more of that equipment will be used. We should, therefore, be grateful for the authors' contribution.

Certain impressions are getting around that when an 800 or a 1000 ton refrigerating machine is needed, it can be picked out of an existing plant without being missed. Please understand that I do not intend to infer that the authors have created such an impression or furthered it.

Unfortunately, there can be found a few examples upon which this impression can be truly predicated. They might be the result of ultra conservatism or just plain mistakes, both of which are to be deplored because they hurt our profession and our industry, or the result of what was good judgment at the time the selection was made.

In the design of war plants, we have been confronted simultaneously

[7] Head, Department of Medicine, University of Illinois.

with the vital need for arriving quickly and surely at results and with the need for applying a practice involving unproven factors. The big bomber plant is a complete example. In its internal heat load are two factors—infiltration and moisture migration. Under normal conditions they account for a considerable number of tons of refrigerating requirement although percentage-wise they are small in relation to the whole. But, infiltration runs wild when doors 50 ft wide and 250 ft long are opened wide. On the other hand, considerable advantage of the flywheel or storage effect can be taken for relatively small buildings. This applies to the bomber plant quite realistically because it contains thousands of tons of steel and other substances but nothing is known of the true weight of this factor.

We are making good progress toward the development of such factors and gaining experience with them but much is yet to be learned about buildings more than 1000 ft wide, several thousand feet long and 50 ft or more in height. In our current experience and knowledge, the final responsibility for predicting the amount of refrigeration required for one of these plants is not to be taken lightly.

Too few of our plants have been designed upon the principle of sacrificing ventilation under the extremes of summer and winter but increasing it as outside conditions moderate. This can be done with relatively simple control which will, as outside conditions moderate, increase the volume of outside air up to predetermined limits. First cost is reduced by sacrificing under the extremes. The higher standard is maintained at all other times with a slight increase in operating cost.

I see two valuable contributions in this paper: (1) the authors bring some of us back to due consideration of the cost of heating which in too many cases has been too completely subordinated by the cost of refrigeration; (2) the authors are campaigning upon a sound engineering and economic basis for a more rational method of determining outside air or ventilation.

W. F. Wells, Philadelphia, Pa. (Written): The method of analysis of ventilation, so effectively applied by the authors, as dilution of impurities in vitiated air, can be extended with appropriate modifications to the removal of air-borne infection. Medical belief that air was not important in the spread of disease, current ten years ago, has been rapidly changing to the conviction that deficiency in ventilation is responsible for much epidemic spread of respiratory contagion during the winter. Medical schools taught that germs, expelled in sneezing and coughing in the form of droplets, fell to the ground within a radius of an arm's length within a few seconds of time, as had been shown by Flugge by exposing agar plates. Infection of air, therefore, was believed to be limited to a few feet and a few seconds, and could not be a problem of concern to ventilating engineers. These larger droplets which settled on the plates were shown, however, by the air centrifuge, to be relatively few compared with the fog of smaller droplets expelled in sneezing and coughing, which evaporate and leave tiny but infectious residue floating in the air until finally inhaled or vented or otherwise destroyed. Studies during the past 10 years also indicate that the dilution afforded by increasing normal winter ventilation tenfold would control the dynamic spread of epidemic air-borne infection. Furthermore, air disinfection has been demonstrated to be an equivalent of sanitary ventilation.

The authors resolve ventilation into three factors: *First*, dilution by pure air replacements; *second*, effective dilution with recirculated purified air; and *third*, infiltration or the inevitable dilution due to lack of tightness in enclosing walls. The last is held to be of minor importance while the second is held to be more economical than the first. The first two, however, are inadequate to meet the demands of sanitary ventilation. Disinfection of room air for purposes of simplicity regarded as analogous to infiltration, becomes the prime effective diluting factor in contagion control. The rate at which live germs are removed from an enclosed space can be equated to the rate of dilution by air change, and expressed in equivalent air change. Measurement of sanitary ventilation by bacteriological methods depends upon determination of rate of removal of a standard test organism contributed at one point and sampled at another. Since all organisms may not be equally sensitive to a disinfectant, a unit of effective dilution equivalent to one air change is defined as a lethe. For practical ventilating purposes, we may consider a lethe and an air change to be equivalent.

Extensive tests have shown a foot lethe per minute (sanitary equivalent of a cubic foot pure air replacement) to be theoretically attainable by approximately a milliwatt foot (milliwatt acting through a foot distance) of 2537 Å radiation. In irradiation, however, 25 per cent efficiency without undue exposure of the occupants would be excellent practice.

In hospital operating rooms, where disciplinary precautions make irradiation of the whole space practicable, a thousand lethes per hour can be attained. Ultraviolet light barriers have been designed which remove 99 per cent of organisms drifting through on ventilating currents. High values may be necessary to prevent hospital cross infection where the sick are housed and dust may be infected. In the control of epidemic spread of contagion, where the well congregate in public gathering places, such high effective dilutions are not required to control epidemic spread of air-borne contagion. In terms of school ventilation, 500 ft lethes per minute (or equal number of cubic feet of air replacement) would seem to be adequate.

C. S. Leopold, Philadelphia, Pa., stated that air washers were quite effective as decontaminators. It was pointed out that while the authors' fuel saving computations were based on an unoccupied building, it would be less in an occupied one in which usually industrial processes would make heat unnecessary until the outside temperature fell below 50 deg—a reduction in degree days of about one-third. In many plants the industrial exhaust far exceeds the ventilation requirements.

Mr. Leopold complimented the authors on the excellency and value of the paper and on the apparatus described.

Authors' Closure: One of the questions raised is that the application of air reclamation through decontamination already has a wide background both in controlled research and, more particularly, in extensive actual practice. Much reliable laboratory and field data have been accumulated and are being augmented continuously by research and through field observation. It is encouraging that, thus far, it is more correct to report that, rather than *complaint records* the tabulation is almost entirely a *satisfaction record*. Actual polls of occupancy reaction have been taken with decidely favorable results, although it is recognized that wider sampling will improve their value. Thus the importance of the valued suggestions by Dr. Keeton and Mr. Fife are acknowledged. It was only because much of this history is intimate to the commercial development of the product that it was considered more objective to omit a detailed account of this experience.

Another question raised is that the latitude of the ventilating engineer in determining both the ventilation requirements and the respective outside air conditioning load should be accented. It was not the authors' intent to establish arbitrary standards nor to exaggerate results. The substitute ventilation proposed is but a contribution to the air conditioning system, the design of which is the responsibility of the air conditioning engineer. It is fully appreciated that each job has its individual conditions and requires its independent study. Not every condition will offer an opportunity for economy through air recovery, nor will results necessarily duplicate those cited in the example given. The note of warning by Messrs. Lewis and Leopold is, therefore, pertinent and very valuable. It is necessary, however, to take issue with two assumptions by Mr. Leopold.

The function of the air washer is primarily to cool, humidify or dehumidify air. There is to our knowledge, no evidence to support the assumption that it contributes appreciably to the extraction of gaseous or odorous impurities from air and there is considerable experience to the contrary.

The assumption that the examples in saving were based upon an unoccupied building is mistaken. Occupancy was given consideration in the examples cited both in the text and in the oral presentation of the paper.

The enlightening discussion contributed by Dr. Wells is greatly appreciated and the developments in infection control in ventilation will doubtless result in the continued development of parallel means to cope with this problem.

Converting recirculated air for a portion of the ventilation demand is valid to the extent that it contributes to economy. If its possibilities will be considered by the designing engineer for each particular job, the authors feel that this paper will have served a useful purpose.

Proceedings of Semi-Annual Meeting 1943

Pittsburgh, Pa.

William Penn Hotel

M. F. BLANKIN
President

WITH AN attendance of 300 members, guests and ladies, the Semi-Annual Meeting of the Society opened at the William Penn Hotel, Pittsburgh, Pa., June 7th. Despite the fact that the program was tailored to meet wartime conditions the interest of Society members was evidenced by the proportion that were in attendance compared with the small number of guests. All four technical sessions were heavily attended and the number of Technical Committee Meetings was an indication of the importance of the wartime semi-annual conferences. The Council held two meetings and regular meetings were also held by the Committee on Research, War Service Committee, Guide Publication Committee and the Nominating Committee.

First Session—Monday, June 6, 9:00 A. M.

Pres. M. F. Blankin called the Semi-Annual Meeting of the Society to order in the Urban Room of the William Penn Hotel on Monday morning June 7, and introduced G. G. Waters, President of the Pittsburgh Chapter.

Mr. Waters presented Frank L. Duggan, President of the Chamber of Commerce of Pittsburgh who in his welcoming address spoke of Pittsburgh as "the arsenal of the allies." He made a brief reference to the historical high lights in Pittsburgh and referred to its industrial production during World War I.

In a brief response, President Blankin expressed the appreciation of the members for the cordial greeting and also the pleasure it gave him to see the fine attendance at the opening session. Mr. Blankin then gave a brief report as President of the Society and said that a great many difficulties had been encountered this year not only because it was a war year but also because our view point and objectives in research and other Society activities had to be revised. He announced appointment of Carl H. Flink, as Technical Secretary of the Society and said that it was expected that an important announcement regarding research activities would be made before the conclusion of the meeting.

President Blankin said that he had done considerable traveling in visiting Chapters during the past three months and had addressed 18 groups. He also found in three other cities that there was a desire for the organization of local chapters, and a great many potential members of the Society. He said that considerable time and effort was being spent on membership work without any special campaign and that the results have been gratifying and he believed that the goal of 400 new members in 1943 would be accomplished. He requested the cooperation of the members in the work of the Membership Committee and suggested that many men were waiting to be asked to join the ASHVE.

Lester T. Avery, chairman of the Committee on Constitution and By-Laws presented an amendment offered by a petition of Canadian members from Toronto, Montreal and Winnipeg. He read the amendment to Art. B-XI as follows:

Section 1—When so directed by the Council, the Chairman of the Finance Committee shall invest such portions of any funds of the Society, as determined by the Council, in securities of the United States Government, *in securities of the Government of the Dominion of Canada*, or in securities legal for the investment of funds of savings banks of the State of New York. Not less than one-half of such invested funds shall be in securities of the United States Government. All investments shall be approved by the Council.

He pointed out that the change in the present section was the addition of the words, "in securities of the Government of the Dominion of Canada." Mr. Avery's motion for adoption was seconded by Professor Rowley and by vote of the members present, it was unanimously adopted.

President Blankin then called on Mr. Avery to present a resolution from the members of Northern Ohio Chapter which he read as follows:

At the regular May Meeting of the Northern Ohio Chapter of ASHVE held at Cleveland Engineering Society Club Rooms May 10, 1943, the following motion was unanimously passed: The members of the ASHVE who constitute the membership of the Northern Ohio Chapter believe there should be a more direct connection and responsibility between the several chapters and the National Society, and

The subject should be carefully considered at this time by all members, and

In order to accomplish this purpose Lester T. Avery is instructed to offer the following resolution from the floor at the

Semi-Annual Meeting of the Society in Pittsburgh in June 1943, to wit:

Whereas, the National Society members may not belong to a Local Chapter unless they separately apply for admission and pay local chapter dues, and

Whereas, Local Chapters may not admit to membership anyone who is *not* a member of the National Society, and

Whereas, the nominations for National Officers are the responsibility and privilege of the Chapter representatives, and

Whereas, the National Society seeks the help of these several Chapters in securing new members, in carrying on Society activities, in serving as host to annual and semi-annual meetings, and

Whereas, the continued growth and strength of the National Society is directly related to the growth and strength of the several Chapters,

Resolved, that a special committee called the Chapter Relations (Development) Committee shall be appointed by President Blankin which Committee shall consist of three members of Chapters, only one of whom may be a present officer or Council member of the Society,

And this Committee is to investigate the subject of Chapter-Society relationship and report in writing at the next Annual Meeting in January 1944, its recommendations as to:

1. A plan whereby each member of the National Society becomes a member of a Local Chapter;

2. A plan for the geographical boundaries of each Chapter thus determining its membership on a convenient geographical basis;

3. A schedule of National dues and Chapter dues taking into consideration the possible financial support of the Chapters by the National Society;

4. Such other matters that may be considered pertinent to this subject.

This report is to be considered on the floor of the meeting and if accepted and approved by the majority vote of members present, it shall be referred to the committee on Constitution and By-Laws to prepare amendments if any are required in order to carry out the recommendations, which amendments shall be submitted to the membership for approval as provided in the constitution.

Mr. Avery moved the adoption of the resolution and the appointment of a special committee by the President of the Society. The motion was seconded by T. T. Tucker, Atlanta, Ga.

In reply to questions about the membership Mr. Avery gave some statistics regarding the Society membership — 1925 — 2372; 1926 — 2712; 1939—3067; 1940—3147; 1941—3320; 1942—3132; 1943—3006. It was his opinion that there should have been an increase rather than a loss during the past four years which was a period of great progress in the industry. He stated that approximately 70 per cent of the Society membership also held Chapter Membership and he thought that the best way to increase the strength of the Society is through the establishment of new chapters and the strengthening of existing chapters.

Mr. McIntosh, Pittsburgh, said that the resolution brought several questions to his mind, for example, what happens to a man who is far from a Chapter center? What is the necessity for financial support of the Chapter? Why is it not possible for a Chapter to carry its own financial responsibilities? He expressed the hope that there would be some discussion of these points for the benefit of the proposed Committee as he believed that before any action is taken that the opinion of a cross-section of the Society membership would be desirable.

V. J. Jenkinson, Toronto, thought that a plan could be developed which would provide better coordination between the various Chapters and the national organization and that something could be done for the guidance of incoming Chapter Presidents and Secretaries and Committee Chairmen.

President Blankin said that for the information of members, there was a Chapter Relations Committee, whose duties included the operation of the Speakers Bureau for the benefit of the Chapters and the resolution would provide for a Chapter Development Committee to report on the matters which have been brought up.

Mr. Campbell noted that a speaker had requested some activities that would aid Committee Chairmen in the various Chapters, and he stated that on three occasions as Chairman of the Membership Committee of the Society he had been unable to get the names of the local membership chairmen because of his inability to get replies from Chapter Secretaries. This year he had requested the Chapter Delegates to turn the matter over to the Local Membership Chairman and the results have been better. It was his opinion that chapters were not cooperating, rather than the national organization.

Mr. Avery said that no decision should be made on any of the points brought up but it was desired that a committee be appointed to study the various questions involved. He thought that the Committee could aid in correcting the situation described by Mr. Campbell. He also thought that the Committee could outline a plan regarding the necessity for Chapters in places where they would not be an expense to the Society but would contribute to its growth.

Before calling for a vote on the question, President Blankin commented that there seems to be an erroneous impression that the present Officers and Council are not interested in the formation of new Chapters and he wanted to correct it as the formation of three new Chapters is under consideration at the present time. When the vote was taken, the majority favored the adoption of the motion.

President Blankin then introduced S. H. Downs, First Vice President, and Dr. C.-E. A. Winslow, Second Vice President, and he asked Mr. Downs to take charge of the meeting during the presentation of the first paper.

Mr. Downs called attention to the innovation on the program which indicated that a time schedule would be followed. He then introduced H. F. Randolph, Utica, N. Y., who presented the paper, Performance of a Residential Panel Heating System by H. F. Randolph and J. B. Wallace (complete paper and discussion to be published in August 1943 ASHVE Journal Section, Heating, Piping & Air Conditioning).

At the conclusion of the discussion, President Blankin resumed the Chair and the meeting adjourned at 11:45 a.m.

A get-together luncheon was held in the Cardinal Room of the William Penn Hotel, at 12:15 p.m. and at the conclusion of the luncheon, G. G. Waters, president of the Pittsburgh Chapter introduced the head table guests and then presented Howard Coonley, Director, Conservation Division, War Production Board, Washington, D. C., whose subject was Fuel Conservation.

Fuel Conservation

By Howard Coonley,* Washington, D. C.

The nation faces a more acute fuel crisis than anyone imagined possible a few years ago. There was considerable talk of fuel shortages last winter but the fact that we squeezed through somehow by the *skin of our teeth* led a large percentage of our population to believe that the situation was not so critical then as it was pictured, and may now cause them to discount the prophecies of a very much greater shortage for the coming winter.

This impression must be erased as quickly and as completely as possible. All indications point to the inevitable conclusion that the American people will have to get along with less fuel this winter than they have heretofore thought possible. With oil stocks already down to 27 per cent of normal on the eastern coast, there can be nothing but pessimistic views of the situation expressed in Washington.

The proper thermal environment, as you of all people know, is one of civilization's greatest contributions to mankind. We have become so accustomed to this environment that the lack of it may prove one of the greatest demoralizing factors during the war. The American people will face that fact and that danger this winter.

*Director, Conservation Division, War Production Board.

[1]P.A.W. release, May 20, 1943.

The War Production Board has under consideration, the problem of reducing the fuel requirements of the nation in a dozen different ways. The requirements involve such fantastically high figures that even a small percentage of saving becomes an objective of vast magnitude. In the heating field alone, a 1 per cent saving would amount to 1,720,000 barrels of oil[2],—the equivalent of 7,224 tank cars. A 1 per cent saving of heating coal would amount to approximately 1,800,000 tons[3] or 36,000 car loads. There is a possibility of making many of these 1 per cent savings.

There are many factors involved in this fuel shortage. One of the primary ones is the lack of transportation facilities. The transportation systems have done an almost impossible job. The magnitude of that job is reflected in the following figures: Before the war there were practically no oil deliveries to the eastern seaboard by rail. Now the railroads are delivering practically all of the oil up to 950,000 barrels a day to the eastern seaboard. Before the war, tankers delivered 1,400,000 barrels per day[4] to this territory; today they are in the Navy. The fact that our railroads have managed this almost complete switch-over on such a gigantic scale has saved the nation from a major disaster.

They have an increasing number of demands placed upon them and provisions must be made to reduce this tremendous fuel transportation problem which they have, up to now, carried. Peculiarly enough, in the field of residential heating, it is on the east coast—which requires the longest transportation—that the bulk of the heating oil is used. Two-thirds of the 3,500,000[5] dwelling units in the country heated by petroleum products are on the eastern seaboard. There is also a higher proportion of oil heated homes to non oil heated homes on the eastern seaboard than in any other part of the country, for instance 45 per cent in Rhode Island, whereas it is less than 2 per cent in some of the southern states. In the country as a whole, only 10 per cent of the homes are heated with petroleum products.

Information developed from time to time by you and your associations has convinced us that a substantial reduction in these fuel requirements can be made through the intelligent application of your findings, and that is what the War Production Board is contemplating. This is an emergency. What is needed is quick action. We will have to let refinements go by the board in the interest of speed. The theoretical possibilities of fuel conservation reach fantastic proportions when all possibilities are thoroughly explored. Still, one half, or even one third of the theoretical is a goal which would inspire the cooperation of even the most thoughtless individual, if the opportunity were properly presented. Voluntary cooperation should be tried first, since carefully worked out mandatory regulations will require lengthy discussions and careful charting through seas of legal red tape. This cooperation should not be difficult to obtain, especially if the findings of your and other associations are properly presented to the public. Your reports on fuel conservation possibilities provide an inspiring basis for such a program.

For instance, one organization[6] reports that their survey indicated that only 60 per cent of eastern oil heated homes have any weather-stripping, resulting in a loss of almost 200,000,000 gal of oil per season in district No. 1 alone. This amounts to 6 per cent of the fuel oil sold in that district. It would require only a small amount of weather-stripping to save this 200,000,000 gal. In fact, as one company points out, if zinc weather-stripping were used on an average house, 70 lb of zinc would save from 300 to 400 gal of oil, or as much as is saved by a ton of ordinary insulating material. Now, we are not at this time recommending the use of zinc for weather-stripping because it might be entirely impossible to allocate zinc for even such a tremendous return.

Many weather-stripping installations can be made without the use of any critical materials; for example, wood strip and felt will also do an admirable job. That this saving is not fantastic has been more than proved by many research agencies throughout the country ranging from Governmental Agencies to Fuel Associations and University Research Laboratories.[6]

All these estimates indicate that on the average house, from 15 to 20 per cent of the fuel can be saved by means of proper weather-stripping. If these facts are properly presented to the home owner, it is probable that for the benefit of his own pocketbook, if for nothing else, he will proceed to weather-strip either in the home-made fashion or by a more deluxe job done by experts. It is at this point, however, that Industry and Government must cooperate. It is up to one to advise and convince the home owner that it would be worth his while to make an investment in order to get a saving of two or three times the amount spent within a few years. It is up to the other to convince him to do his work with non-critical materials and thereby contribute his share towards the fuel conservation program.

Another conservation possibility arises in the field of hot water heating. The householder should be impressed with the fact that 10 per cent of our fuel oil is used in homes for heating water. Here substantial economy is possible if home owners cooperate. Homeowners would keep their hot water at 135 deg if they knew that for every 10 deg above that temperature, 8 per cent more fuel is required, and they cannot use such high temperatures of water anyway.

I also note with interest that many publications in your field estimate that the efficiency of fuel utilization of many heating installations can be raised by 20 to 30 per cent through expert analysis and tune-ups. Your findings in this field indicate that vast numbers of heating systems are improperly regulated as to on and off cycles, nozzles and drafts, which, when corrected by persons who *know how*, will stretch out the fuel oil ration card to a comfortable extent.

The coal furnace, now operated by so many of our millions of people, has come to be looked upon as something which will just run by itself. Surveys indicate that in some areas only 5 per cent are satisfactorily adjusted.[7] And yet, as has been so amply demonstrated, properly reconditioned operating and regulating equipment would save most owners 25 per cent of their fuel bills. Of the 11,000,000 tons of anthracite coal used in homes 23 per cent or 2½ million tons could be saved by automatic controls to keep the inside temperature from rising above 70 deg. This means 17 days of mine production and almost 5,000,000 ton miles of transportation, as well as 9 million car miles, and would save 2½ million gallons of gasoline on retail truck deliveries. This refers to anthracite only.[8]

The insulation of homes, of some of our most dilapidated structures, will save as much as 40 per cent of the fuel bill. Many types of insulation are non-critical and can be installed very simply and at a low cost. The possibilities along this line on the average uninsulated house amounts again to about 25 per cent.

Common sense methods of home management by the housewife can also save more than 10 per cent of the fuel bill. The constantly opened doors by children at play; the fresh air addict who sleeps with all the bedroom doors and windows open; the charming fireplace, racing to empty the house of its heat faster than the heating system can put it in; all these are dubious luxuries which we cannot afford this winter. Home management hints on all these points will be broadcast. We shall inform homeowners that if they maintain a 60 deg temperature at night they save 5 per cent or more of their fuel; if they maintain 68 deg instead of 70 deg during the day, they save 7 per cent, and for those who over-heat, we will

[2]Office of Civilian Requirements states that 172,000,000 bbl oil used for heating in 1941. (By telephone).
[3]Office of Civilian Requirements.
[4]P.A.W. release.
[5]U. S. Department of Commerce H-13, No. 5, September 9, 1942 *Housing*. Also, No. 3 of same series.
[6]Oil Heating and Merchandising News Fuel Oil and Oil Heat, August 24, 1942.
[7]Coal Heat magazine, April, 1942.
[8]Technical Advisory Board of Anthracite Industry.

point out that it takes 3½ per cent more fuel to heat the home at 71 deg than at 70 deg. The home owner will be healthier and wealthier if he takes these hints seriously.[9]

The use of small radiant electric heaters to provide local and concentrated heat in bathrooms and at breakfast tables will save a tremendous amount of fuel. Their use in the spring and fall instead of operating the central heating system, can also do much to cut fuel consumption.

Many of our homes, as well as industrial establishments, have heating systems without any of the automatic controls which add so much to the fuel efficiency of the system. The possibility of allocating more materials for the production of heating controls for installation in these systems is being given consideration. The most expert advice is needed on this point to determine whether we can trade the critical materials and labor involved for the 15 to 20 per cent reduction in fuel consumption that such installations frequently return.

We have then a problem with many ramifications. *Not all of these conservation measures can, of course, be applied to any one installation.* However, a successful use of the facilities and knowledge at hand could probably save 30 per cent of the 180,000,000 tons of heating coal and 30 per cent of the 170,000,000 barrels of heating oil. This represents one of the greatest conservation possibilities we have ever faced: the possibility of saving 54,000,000 tons of coal and 51,000,000 barrels of oil. There is little need to translate this into units of labor and transportation. Nevertheless, it represents 214,200 tank cars of oil and 1,080,000 car loads of coal. This is indeed a challenge to all who are in a position to help.

Now, what plans are on foot to obtain as much of this 30 per cent conservation as is practicable? There are many in the War Production Board who are thinking of this problem. However, one must not expect to find any set pattern or procedure for such a major task. The Conservation Division is one of the many agencies in Washington involved. We are an advisory and not an operating agency of the War Production Board. In this role, we are constantly seeking help and advice in developing recommendations to the proper WPB operating divisions. Consequently, this problem represents one of our major interests at the moment. As I see it, the problem breaks down into four parts:

1. Increasing the efficiency of the fuel consuming unit and heating system by:
   - *a.* Inspection and adjustment.
   - *b.* Providing the necessary automatic controls.
2. Preventing heat losses by:
   - *a.* Promoting proper home management.
   - *b.* Weatherstripping.
   - *c.* Storm doors, sash and entrances.
   - *d.* Insulation.
3. Relieving oil consumption in critical areas by conversion to coal in:
   - *a.* Large apartment houses.
   - *b.* Institutions.
   - *c.* Commercial and industrial buildings.
4. Reducing total fuel consumption by:
   - *a.* Eliminating unnecessary lighting.
   - *b.* Eliminating casual heating of non-essential buildings.
   - *c.* Proper use of portable radiant heating units.

A nation-wide fuel conservation program has already been started by means of radio and newspaper campaigns. We hope that it will develop along the lines indicated above with the intelligent cooperation and assistance of all interested parties.

In the case of part 1 of the program (increasing the efficiency of the heating system) it will be necessary to obtain the most wholehearted cooperation, not only from industrial technical associations such as yours, but from all interested government agencies. A decision on this part of the program will soon be made.

On part 2 (preventing heat loss), there is, of course, no limit to the amount of publicity that can be given to some of the points since they involve no critical materials or labor. Some of them require only a little common sense on the part of the person who desires to help his country, and at the same time, his pocketbook, by proper home management. We are not yet certain, by any means, that even sufficient lumber for the necessary storm windows can be allocated. Storm windows, to a considerable extent, require the same type of lumber as is used for boxing and crating, and for which there is an increasing demand. There is more lumber at the present time going into boxing and crating alone, than was used in all construction in recent years. However, there are innovations that can be used as substitutes for regular storm windows. Cellophane pasted on cardboard frames, or by some other means attached to the inside of the window frame, will accomplish the same conservation that storm windows will give. This saving reaches an unbelievably high figure and should be number one on each home owner's program for the coming winter. Although some types of insulation are critical, there will be plenty of both mineral wool and rigid insulation. The labor involved for some of this work, however, may be critical. Therefore, it is advisable to concentrate on those portions of the house which are most readily insulated, for instance, the attic floors.

Part 3 of the program (converting from oil to coal) again involves the use of highly critical materials and facilities. Conversion from oil to coal in those areas where oil shortages exist will be necessary and has already to a large extent taken place. In fact, conversions already in place have reduced the total oil consumption at a rate of 44,000,000 barrels per year.[10]

Part 4 of the program (reducing fuel consumption) has tremendous possibilities. The elimination of unnecessary lighting, it is estimated, will save nearly 2,000,000 tons of coal, 600,000 barrels of oil and 6,000,000 cubic feet of gas. This will reduce the transportation load by an estimated 630,000,000 ton miles of coal transportation and 36,000,000 ton miles of oil transportation. It would, of course, involve great inconveniences. But war is full of inconveniences and this program is seriously being considered. There are also thousands of buildings and halls which are only occasionally used, but which require a disproportionate amount of fuel to heat them up for this short time. This practice should be discarded for the duration.

Such is the program and such are the thoughts which are passing through the minds of many of us in Washington. If they sound drastic, bear in mind that we have the tremendous goal of a 30 per cent reduction of fuel before us. It is a goal worth lifting our sights for. You heating and ventilating engineers know better than any other group the difficulties we face in deciding the course to follow in working out this program. We need your help. Your suggestions will be enthusiastically welcomed. More than ever before the War Production Board looks to groups like yours for help and guidance. You have already been generous in your assistance. We urge you to even greater effort in our common cause.

Second Session—Monday, June 7, 2:00 P. M.

The second session was called to order at 2:00 p.m. by Pres. M. F. Blankin and he introduced Dean J. A. Goff, Philadelphia, who presented his paper, Final Values of the Interaction Constant for Moist Air, by John A. Goff, J. R. Andersen and S. Gratch (complete paper published in June 1943 ASHVE Journal Section, Heating, Piping & Air Conditioning).

W. H. Carrier, Syracuse, N. Y., pointed out that Dalton's Law is a rule that applies at low pressures because the interaction constant is not a large factor at ordinary pressures.

Dean Goff explained that it was easier to use the accurate data presented than to use Dalton's rule. Further, while Dalton's rule would obtain a value of the weight of water per pound of dry air at saturation for 68 F and atmospheric pressure, within ½ of 1 per cent, the error would be 15 per cent at 100 psi and 30 per cent at 200 psi.

John James, Cleveland, Ohio, asked Dean Goff to explain how the interaction constants obtained in the

[9] *Principles of Economic Heating* by National Association of Building Owners and Managers.

[10] P.A.W. release 169, May 20, 1943.

study would change the lines on the psychrometric chart.

Dean Goff replied that in all applications of thermodynamics or engineering there are two fundamental propositions: the law of conservation of energy and the law of conservation of mass.

In air conditioning it is usual to analyze the case of steady flow in which the fluid moves through a duct. The air stream moves across a fixed section of a duct and the energy it carries with it is called enthalpy.

Because of the law of conservation of mass it is necessary to account for the total weight of water and total weight of dry air crossing any section. The pounds of water per pound of dry air is a ratio which the Society has used for years. This ratio is now called the humidity ratio.

Enthalpy and the humidity ratio are fundamental coordinates for the psychrometric chart. In order to reduce the length of the chart it is useful to subtract out a thousand times the ordinate in plotting the values. Dean Goff then illustrated the construction of the psychrometric chart as a Mollier chart and pointed out its advantages in solving air conditioning problems.

C. M. Humphreys, Pittsburgh, Pa., commented on the advantage of the Mollier chart over the customary psychrometric chart in solving air conditioning problems.

Dean Goff concluded by stating that any air conditioning problem which was amenable to thermodynamic analysis could be solved more simply on the Mollier diagram than on any other chart.

At the conclusion of the discussion, President Blankin acknowledged Dean Goff's expression of thanks for the cooperation of the Society and said that they had made a splendid contribution to the fundamental research sponsored by the ASHVE.

The meeting was then turned over to First Vice President S. H. Downs, who presented the author of the paper, Study of Actual vs. Predicted Cooling Load on an Air Conditioning System by J. N. Livermore (complete paper published in April 1943 ASHVE Journal Section, Heating, Piping & Air Conditioning). Mr. Livermore presented his paper with slides and the discussions follow.

Thomas Chester, Detroit, Mich. (Written): In any type of engineering it is desirable to ascertain how results compare with planned performances, as this is full scale research. Consequently the analytical tests set forth in detail in this paper are interesting and useful.

It is reported that during the morning of July 7, the thermostat settings were progressively raised, which resulted in partial unloading of the refrigerating equipment, due to heat absorption by the contents of the building and the interior surfaces of the building itself and also the contained air, in rising to a higher temperature. The introduction of this variable seems a procedure of doubtful value in making performance tests.

However, it might be interesting to make a separate investigation along this line under stable load conditions, as on a cloudy day with approximately uniform outdoor temperature, preferably on a Sunday when there would be little fluctuation in the number of occupants, and with a constant lighting load. This would show the rate of heat exchange between the fabric of a large office building and its air contents and also the rate of moisture exchange. The latter would be new but we have somewhat of a line on the former, indicated in the time required to heat a building in winter.

It is inadvisable to accept without proper understanding the statement that variations in water temperature for short periods between 54 and 40 F produced little effect on the average moisture content of the air within the building.

It should be realized that this pertains to this particular job and is not typical of air conditioning installations in general.

The building is large, it is unusually tight against infiltration, and the number of occupants relatively small. Consequently, the moisture load is small, as it is confined to the water vapor given off by the occupants and any residual excess after conditioning in the water vapor content of the outdoor air brought in for ventilation over the water vapor content of the indoor air. Therefore, the gain in the water vapor content of the indoor air would be slow.

Also, the air conditioning is done by coils. The performance would be quite different with an air washer type of conditioner, with which a rise in water temperature would immediately produce a higher dewpoint in the air leaving the apparatus. Even with coils, the gain in the moisture content of the indoor air would be at a more rapid rate in the case of a theater, in which the number of occupants per 1,000 cu ft of space would be much greater than in the case under notice, and hence, the relative and absolute humidity would rise more rapidly.

As stated, no general inference should be drawn from the reported slow rate of change in the moisture content of the indoor air with changes in supply water temperature, as the type of moisture load is the criterion of principal importance.

R. E. Hattis, Chicago, Ill. (Written): I notice that the building walls have a considerable amount of glass brick. Was enough artificial light saved in the spaces near the glass brick walls to compensate for the increased cooling required? On future work would you consider a considerable reduction in the amount of glass brick wall, or even its entire elimination?

I would be interested in knowing whether water was used on the roof to reduce roof sun load, and whether the author would consider it on new work.

I would also like to know about operation of the cooling system with all recirculated air during all or part of the night to absorb part of the stored heat in building construction. If the cooling system was operated for only a part of the night, would it be operated immediately after working hours or just before the starting time the next morning?

The phenomenon of time lag in the heat from lights is interesting and, as the author suggests, is worthy of further research. This paper gave me considerable food for thought, and covered the subject in a comprehensive and interesting manner.

J. H. Walker, Detroit, Mich. (Written): It is not often that the designer of an engineering project displays his calculations alongside of performance figures; nor in fact is it often in heating and air conditioning that any detailed performance tests are made. On both of these points the author deserves commendation.

The paper brings out at least two points which are impressive. The first one is that there may be an important time lag in the *internal* cooling load. We have always recognized, and made efforts to calculate, the time lag of heat flow through walls and roofs; but here is an apparent time lag in the effect of the internal lighting load. At any rate that explanation seems best to fit the test results. How unique that time lag effect is to this particular building design or whether it might be expected in other buildings cannot of course be stated. More work of a similar nature in other buildings is certainly needed.

Secondly, the paper shows how important are the design assumptions which must be made regarding such matters as the number of occupants, number of lights in use at the time of the peak cooling load, etc. Reasonable accuracy in those respects may be far more important than refinement in thermal calculations.

More studies of this sort are highly desirable in order that design methods may be improved.

W. H. Carrier, Syracuse, N. Y., remarked that except in the South time lag in walls can practically be neglected if margins are provided for other allowances which are required. He emphasized that time lag data obtained for installations in the North should not be used in drawing conclusions for southern states such as Texas or Louisiana. An illustration was given of one air conditioning installation in which the allowances were so small that it was necessary to distribute the cold air to the east side in the morning, to the south side at noon and to the west side in the afternoon. The installation was, however, satisfactory but it had to be brought up to its highest performance in order to meet the conditions encountered.

Air conditioning equipment needs a margin for reducing building temperature after the building has absorbed a large amount of heat during a period of high outside and high inside temperature.

Dr. Carrier then referred to the capacity of the building construction to absorb moisture and thereby produce a lag when humidity conditions are being changed.

F. E. Giesecke, Urbana, Ill., commented on the time lag of heat liberated by electric lights which apparently radiate (to the floor and equipment) heat which is later released gradually to the cooling system.

Mr. Halsted pointed out that the time lag reported was a characteristic of the building described and that

whereas in this case the pans above the lights absorbed a fair proportion of the radiant energy there would have been less lag in the effect of the lighting load if the lights had been exposed directly under a flat ceiling.

L. T. Avery, Cleveland, Ohio, cited one installation in which the cooling system was easily handled at less than maximum capacity if operated at night but which was inadequate to pick up the load in the morning if it were turned off at night. This was due to the heat storage in the ceiling due to sun effect in the day time and a high Mazda lamp load.

The author concluded the discussion by remarking that the maximum heat that could be carried away by an air stream passing over a lamp was approximately 30 per cent and that the remainder must be delivered by radiation to the surfaces and surrounding objects.

He stated that it was not the intention to suggest that the chilled water temperature need not be controlled although in this building close control did not seem to be essential.

Author's Closure: Referring to Mr. Hattis' remarks, glass brick was not used primarily to give more natural light near the outside walls. It was chosen because it has the insulating value of double sash while having almost no air infiltration. It also eliminates window washing and window maintenance generally. In the five years since the building has been built the glass bricks have not been washed.

The cooling load caused by the glass brick is less than that caused by an *equal area* of window unless the window has exterior awnings. We do not know what area of window would be *equivalent* from a lighting standpoint.

We did not use water on the roof. While that scheme was considered at the time the building was designed, it was felt that since the roof load was a small part of the total and the mechanical difficulties of maintaining a pool of water on a roof are certainly not negligible, such an installation could not be justified. Instead, the roof was insulated with two inches of cork board.

Replacement of air required for the toilet exhaust system caused about 0.70 building volume change per hour and just about satisfies the minimum fresh air requirement at all times. Aside from this, the suggested operation on all recirculated air at night has always been a part of our operating practice. Generally all refrigeration is cut off at the time building use ceases, and is started again shortly in advance of reoccupation next day. During certain sustained periods of extremely hot weather some refrigeration has been necessary all night.

The points mentioned by Mr. Chester are pertinent. I would like to repeat, however, that the main object of this test was to analyze loads encountered when operating in the usual manner, and in this building the usual manner involved an increase in indoor temperature as the outdoor temperature rises. This method has much in its favor, and is no doubt used in many other buildings. Mr. Chester is correct in his reference to the effect of changing thermostat settings of July 7; however, this did not apply to the data set forth for the morning hours of August 2, 3 and 4. The building was thus tested in both ways,—with a rising indoor temperature and with a stationary indoor temperature.

As to the effect of the control of chilled water temperature, it was not intended that the discussion in the paper on this point was applicable to buildings generally. The paper deals with a specific building. The author does not entirely agree with Mr. Chester but that point is incidental to the subject of the paper.

Mr. Walker is one of the author's business associates and his natural modesty does not let it appear in his comments that it was largely through his efforts that this test work was made possible. His comments on the results of the work are indeed generous; they also serve to underline what the author believes to be the true significance of the findings of the test.

Dr. B. M. Woods, Department of Mechanical Engineering, University of California, presented the paper, Spray Nozzle Performance in a Cooling Tower, by L. M. K. Boelter and S. Hori (complete paper published in May 1943, Journal Section, Heating, Piping & Air Conditioning).

W. H. Carrier, Syracuse, N. Y., described, with blackboard illustrations, some cooling tower experiments conducted in 1908 by A. E. Stacey and himself in which the tower was used both to cool the air with water and to cool the water with air. The tower was about 4 ft square and could be operated at velocities of 400 to 800 fpm.

B. M. Woods stated that Professor Boelter would be very much interested in reviewing the data mentioned by Mr. Carrier.

President Blankin resumed the Chair and expressed the thanks of the Society to Dr. Woods and the authors for their paper. The meeting adjourned at 4:15 p.m.

Third Session—Tuesday, June 8, 9:00 A. M.

On Tuesday morning, President Blankin opened the third session at 9:30 a.m. and he announced the personnel of the Chapter Development Committee as follows: W. A. Russell, Kansas City, Chairman; Albert Buenger, Cincinnati, president of Cincinnati Chapter; and C. E. Price, Chicago, president Illinois Chapter.

The personnel of the Resolutions Committee to report at the final session was also announced: H. H. Erickson, Philadelphia, Chairman; M. W. Bishop, Milwaukee and M. B. Shea, Detroit.

Second Vice-President C.-E. A. Winslow took the Chair and introduced Prof. J. R. Fellows of the University of Illinois, who presented his paper, Use of the Down-Draft Coking Method for Smokeless Combustion, by J. R. Fellows and J. C. Miles (complete paper and discussion to be published in August 1943 ASHVE Journal Section, Heating, Piping & Air Conditioning).

The paper entitled, Field Study of Comfort Reactions of Apartment Dwellers Under Fuel Oil Rationing, by Sallye Hamilton, was presented by the author (complete paper published in June 1943 ASHVE Journal Section, Heating, Piping & Air Conditioning).

Wharton Clay, New York, N. Y., inquired whether further studies were contemplated. He suggested that in buildings such as the Parkchester Apartments, New York City, in which insulation was used between the plaster and masonry walls, there might be a different comfort reaction at lower air temperatures. Neither Miss Hamilton nor Chairman Winslow knew whether further studies would be made.

M. K. Fahnestock, Urbana, Ill., stated that the paper brought out that occupants cannot be physiologically comfortable in temperatures below 73 to 74 F and that increased clothing must accompany fuel oil conservation. The effect of the unit of thermal insulation depends on its location on the body and is greatest on the extremities, particularly the feet. He questioned the desirability of introducing new units such as clo and met which might cause confusion because of the attempt to combine physical science and biological science.

Chairman Winslow stated that the units met and clo had been selected (at a conference of three of the leading laboratories working on clothing problems in the United States and Canada) for use in making clothing studies only.

H. F. Randolph, Utica, N. Y., asked whether anything had been done to introduce shades, drapes, storm windows, etc. and to determine their effect.

E. K. Campbell, Kansas City, Mo. stated that the real opportunity for fuel oil saving occurred in office buildings. Since the quantity of oil used for human comfort is extremely small —2 million gallons in Kansas City as compared with 140 million gallons for all purposes—a 10 per cent saving in oil used for heating would be a very small percentage of the total oil used.

Chairman Winslow mentioned that in other housing projects as well as Hillside Homes a saving of fuel oil was always accompanied by an increase in consumption of gas and electricity, which might be of greater importance next year. He thought that insulation and clothing were the really effective means of meeting the situation of fuel oil reduction.

C. E. Shaffer, Kearny, N. J., inquired whether the health of occupants was affected.

H. M. Hart, Chicago, Ill., inquired why the project had not been converted to burn coal.

Miss Hamilton closed the discussion by stating that all buildings in the Hillside project had been converted to coal except one in which there was some special reason for continuing to use oil. She gave several illustrations of occupants' attempts to increase their comfort by reducing heat loss and mentioned need for educating the occupants in the matter of conserving the available heat. There were in-

stances in which sickness seemed to be traceable to the reduced temperatures.

The third paper on the program was announced by Chairman Winslow who introduced Professor Rowley for the presentation of his report on, Heat Transmission through Insulation as Affected by Orientation of Wall, by F. B. Rowley and C. E. Lund (complete paper and discussion published in this issue, see p. 361).

Professor Winslow introduced P. D. Close, who presented his paper, Graphical Method of Calculating Heat Losses (complete paper published in June 1943 ASHVE Journal Section, Heating, Piping & Air Conditioning). Written Discussions by Messrs. E. V. Hill, Chicago and G. A. Erickson, were read by C. H. Flink, Technical Secretary.

H. M. Betts, Minneapolis, Minn. (Written): This paper provides a long needed short cut method of determining heat losses of smaller structures with a reasonable degree of accuracy. Contractors in submitting bids for heating installations have been forced to calculate heat losses the hard way or to run the risk of guessing wrong and being compelled to complete a contract at a loss. The time spent on heat loss calculations is, of course, lost if they fail to obtain the contract. Many have developed short cut methods of their own but these are based mostly on other buildings of comparable size or some rule of thumb which may be anything but accurate.

As the author states, the method which he has developed should be used with some discretion and should not supplant the regular method as outlined in The Guide. It will, however, find a very definite place in the heating trade and with public utilities. Since it is based on formulae and information contained in The Guide, it will provide a standard time-saving method of determining approximate heat losses in the same way that the method outlined in The Guide is looked upon as the standard method today. The author is to be commended for his work.

G. A. Erickson, (Written): The graphical method presented in this paper for calculating heat losses for small buildings is by far the simplest method we have seen devised.

In roughly checking the author's method with the standard method of determining heat losses used in The Guide, we found the hourly Btu loss results in reasonable agreement and sufficiently accurate for many purposes. The percentage error in some cases was, however, slightly more than the plus or minus 3 per cent mentioned in this paper. This variation between the two methods (which incidentally was larger for insulated houses than uninsulated houses) was due perhaps to the fact that we took into account the floor loss to the basement and used the crack method to determine infiltration loss. We found the results of the two methods approximately the same, however, when we based the infiltration loss on ½ or 1 air change per hour and when we disregarded the floor heat loss in those houses having basements.

We are in agreement with the use of the combined roof and ceiling coefficient for determining heat loss of this portion of the building because of facts brought out in a previous report[1]. A study of the actual air temperatures in the ventilated attics of these four test houses, as compared with the calculated attic air temperatures, indicated the importance of considering the insulation value of the roof. The close correlation obtained between the actual and calculated heat losses of these test houses was due in part to the consideration of heat losses through the combined ceiling and roof, and also to the use of proper basement temperatures in figuring the floor heat loss. The actual basement temperatures recorded in the test houses showed the average unheated basement air temperatures to be 53 F to 57 F during below zero weather. We, therefore, believe the author's method should make some allowance for floor heat loss for houses with basements, especially in colder climates. If the floor loss is neglected, the percentage of error of the final results between the author's method and the standard method (floor loss considered) will, however, be smaller for houses in warmer climates and for houses of ½ or 2 stories rather than 1 story.

The problem of figuring heat loss of 1½-story houses with dormers and shed roof is naturally more complicated than 1 or 2-story buildings because of the broken up areas and variation in wall, ceiling and roof construction. We assume the flat and sloping ceiling areas are to be grouped together and an average combined roof and ceiling coefficient used. On this basis we checked the 1½-story test house (using the author's charts) and found the results fairly accurate when the infiltration loss of the standard method was figured as ½ air change per hour. When the crack method was used for infiltration loss, the variation was increased to slightly more than 3 per cent.

The use of the graphical method for determining heat loss calculation as given in this paper should prove valuable to heating and ventilating engineers, architects, contractors, and others, and is to be especially recommended as a rapid method of checking heat loss, and heating and insulation requirements of residences and other small buildings.

H. M. Hart, Chicago, Ill. (Written): This report may serve as a means of making a rough calculation of fuel requirements for one- or two-story dwellings having 8 ft ceilings and a combined window and outside door area equal to 20 per cent of the outside wall area.

However, I feel that it would be a step backward for this Society to indorse any method based on so many assumptions. For many years we have been concentrating on trying to raise the level of heating engineering by removing the guesswork, and I think a lot of progress has been made.

My early childhood was spent in a house heated by steam radiators. The radiators were constructed of 1 in. pipe screwed into cast-iron bases. The sizes were selected on the basis of 1 tube 30 in. long to 60 cu ft of space to be heated.

My recollection is that we were always warm enough, but I also remember the woolen underwear. The house is still occupied by members of my family and the old radiators are still doing the heating, although the second-floor ceiling has been insulated and storm windows and storm doors are now used. I know it was the best heating system in the town in 1891, but I also know that this is not true today.

For a rough calculation of fuel requirements the Fuel Rationing Division of the OPA has certainly adopted a simple formula, and I am sure many of us have found how rough it could be.

The method suggested by the author is certainly an improvement over that, but I would still hesitate to suggest that it be adopted by OPA for fuel rationing. The idea is good, but it is too limited in its application, and I fear that it might be misused.

E. Vernon Hill, Chicago, Ill. (Written): I believe this paper will find wide use, and the author is to be commended for this ingenious method. I have not had the time so far to study the paper as it deserves, but I gather the impression from reading it over that the curves A, B, C, D, E, and F are plotted from simplified heat transmission formulae. Ordinate and abscissa on the chart represent wall and floor, roof areas, etc., and heat losses. Drawing a horizontal line from the area scale to a diagonal line from the appropriate factor on the curve to zero and dropping down from this intersection to the heat loss scale is the total heat loss for the area under consideration. Figuring heat losses, therefore, by the author's graphic method is as simple as that.

Of course, the danger in using this as well as other simplified methods of making calculations is that the one who uses it is liable to forget the proper use of fundamental methods of calculation and the formulae as set forth in The Guide; but even so, the saving in time and grey matter is still, I think, amply justified. Most engineers and heating contractors are willing to leave the extremely accurate and technical calculations to our college professors and research men; and if the results will check within plus or minus 3 per cent with the older methods of calculation, I feel that this is close enough for all practical purposes. When we consider the coefficients of transmission as they are in The Guide today and compare them with the same coefficient or the coefficients for the same material of 10 years ago, we can excuse any slight discrepancy in values as determined by the chart prepared by the author.

One thing that interests me in examining Fig. 1, which is the full page chart under discussion, is the following: The scales for ceiling, floor, wall areas, etc., and the scales for heating losses are identical on both charts. It would appear desirable, therefore, to combine the two in one chart, thus simplifying the entire procedure. I note in superimposing the two, the

[1] Heat Loss Studies in Four Identical Buildings to Determine the Effect of Insulation, by D. B. Anderson. (ASHVE Transactions, Vol. 48, 1942.)

curves A and E come very close together but could not, I believe, be a serious obstacle to combining the two charts. Possibly there are other reasons I do not appreciate that the author will explain.

John James, Cleveland, Ohio (Written): An ingenious chart has been presented for quickly calculating the heat loss of a residence. This graphical method should serve as a very useful tool in four types of problems such as, (1) estimating the yearly fuel consumption of a structure, (2) determining heat loss savings resulting from the application of insulation and storm windows, (3) sizing and applying conversion automatic heating equipment to existing structures, and (4) making rough estimates of the total cost of a heating or air conditioning system.

Short-cut formulae and charts such as the one presented in this paper have been advocated for the purpose of reducing the engineering charges on an installation. Of course, it is readily apparent that this chart is not useful in designing a heating system, as it is necessary to calculate the heat loss of each individual room for properly selecting the required amount of radiation or air supply.

Many have expressed the feeling that The Guide method of calculating heat loss is too tedious and cumbersome. However, it can readily be shown that such an empirical formula as Carpenter's requires almost as much time to use as The Guide method. In both methods of computation, one of the most time-consuming factors is the time needed to actually measure or scale from drawings the dimensions of the room and window and door areas. After this job is completed, only a short time is required to calculate the heat loss.

It might be appropriate at this time to review briefly the empirical formula suggested by Prof. R. C. Carpenter to illustrate how closely The Guide method compares. Professor Carpenter's formula is as follows:

$$H = (1\,G + 0.25\,W + 0.02\,nC)\,(t_o - t_i)$$

Practically the only difference between this formula, which incidentally many engineers are now advocating in some such form, and The Guide method is that more exacting values of U (overall heat transmission coefficient) are substituted such as 1.13 instead of 1 for single glass, and the actual U value for the wall under consideration instead of the figure 0.25 which is for an ordinary wall. True, this formula does not make use of the crack method for estimating infiltration, but it will be recalled that The Guide suggests that the amount of air leakage can be roughly estimated by assuming a certain number of air changes which can be substituted for n in Professor Carpenter's formula.

Summarizing, it is my opinion that the graphical method presented in this paper will serve as a very useful supplement to The Guide procedure for the purposes previously outlined. Until some method can be devised which will eliminate the necessity of actually measuring a room to determine the heat loss, it is believed that The Guide method offers distinct advantages over any empirical formula now suggested.

R. K. Thulman, Washington, D.C., stated that results obtained by the author's graphical method were in fairly close agreement with short cut methods developed by the FHA. In developing a formula for heat loss the FHA had found a reasonably consistent relationship between all the area through which heat is lost, the cubical contents, and the floor area and therefore, especially since floor area is used as a basis of other computations having to do with the property valuation and underwriting, FHA had adopted floor area as the single factor for determining heat loss. An analysis of 36,000 cases had shown the FHA floor area formula to be consistent with accurate methods for determining heat loss.

Mr. Thulman advocated the use of a formula in preference to graphical solution as its use was more readily comprehended by architects.

The fuel requirement as determined by the author's proposed method was so similar to that obtained by the FHA floor area formula that Mr. Thulman could not understand the desire of the ASHVE president and the War Service Committee for a more accurate formula.

H. E. Lewis, Toledo, Ohio, commended the author for being rather specific in regard to efficiency of heating systems, because of the important effect it has on the fuel consumption. Some factors may affect the fuel requirement 3 to 5 per cent while the efficiency may make a difference of 20 per cent.

C. M. Humphreys, Pittsburgh, Pa., emphasized the limitation of the chart to conventional types of residences and said that it was not intended for individual rooms in which an error in heat loss determined by its use might amount to 20 per cent.

Professor Humphreys suggested that the method advocated in The ASHVE Guide for determination of heat loss could be much more readily used if a form or chart were prepared to provide a logical method of setting down data for the purpose.

H. M. Hart, Chicago, in an oral discussion supplementing a written one reported that the Heating, Piping and Air Conditioning Contractors National Association had found charts preferable to graphs, because of greater simplicity and possibility of longer use before replacement. All calculations were on the chart and they were based on Guide requirements.

Mr. Close stated that an actual comparison would show that in a two-story residence each 1 per cent variation in window area from the 20 per cent assumption would cause an error in overall heat loss of about 1 per cent for regular windows or 15/100 of 1 per cent if storm windows were used.

Ceiling height did not cause an error because actual ceiling heights were used in figuring gross area.

The suggestion of Dr. Hill that the charts be combined might cause some confusion if adopted.

Basement heat losses were neglected because they were very small.

The author had previously been a proponent of the crack method of figuring infiltration but, because of the variation in crack size and the influence of other factors which affected infiltration, he felt that an assumption of the number of air changes would be about as accurate.

In reply to Mr. James the author stated that the chart could be used for individual rooms in one-story residences, but not for two-story residences.

The author disclaimed any similarity of the graphical method to the floor formula method used by OPA.

President Blankin resumed the Chair and said that he wished to make a special announcement of great importance to Society members. He stated that at the January Council Meeting it was decided to enlarge the scope of the Research activities of the Society, because it was felt that this was vital to the life and progress of the Society.

It was concluded that a qualified director of research, who could combine the duties of administrator of the Research Laboratory, liaison officer between the cooperative research organizations of the Society and be in direct charge of the development of the Research program, was needed so the new position, that of Director of Research, was created by Council. The Chairman of the Committee on Research and the Research Executive Committee, were authorized to secure a man with the proper qualifications and after diligent search the Committee and the Council feel that they were most fortunate in being able to choose Mr. Cyril Tasker, Senior Research Fellow of the Ontario Research Foundation, as the new Director of Research.

C. M. Ashley, Chairman of the Committee on Research, escorted Mr. Tasker to the rostrum. President Blankin expressed his pleasure in being able to welcome Mr. Tasker as the new Director of Research and in response Mr. Tasker said "Mr. President and Members of the Society: I think your President has rather put it the wrong way around. The honor is entirely mine. I very deeply appreciate the trust which the Society through the Council and the Committee on Research, has seen fit to put into my hands. I can pledge you one thing, and that is my whole-hearted and undivided attention to my duty. I can pledge you a sincerity of purpose. I can pledge you that the Society's name shall be very jealously guarded in all that I do on its behalf. I ask from you your continued friendship and your whole-hearted support. This is a team job.

"We have a tremendous amount of work to do, and we must make sure that our Society's technical activities and the research work stand high, not only on the North American continent but also across the water. I am going to do my best to make certain that we do that. I hope to be

able to take over my duties in September, and I hope to be able, at the 50th Annual Meeting, to report some reasonably good progress. Thank you very much indeed."

The meeting adjourned at 12:45 p.m.

Fourth Session—Tuesday, June 8, 2:15 P. M.

Pres. M. F. Blankin called the meeting to order at 2:15 p.m., Tuesday, June 8 and the first paper entitled, The Economic Factors in Converting Recirculated Air for Ventilation, by H. E. Ziel and Henry Sleik, was presented by the authors, (complete paper and discussion published in this issue, see p. 367). Mr. Sleik gave a discussion of general ventilation requirements and air treatment for air recirculation and Mr. Ziel gave the design problem involved in the practical application in a typical war plant.

President Blankin invited John Howatt, chairman of the Panel Discussion on Will Current Ventilating System Operation Undermine Public Health and Efficiency, to present the other panel members. John Paul Jones, consulting engineer of Cleveland, L. L. Lewis, Syracuse, N. Y., and Dr. C.-E. A. Winslow, New Haven, Conn., Second Vice-President of the Society, were introduced.

Chairman Howatt: As the announced subject was selected because of a growing practice in government-financed defense projects and FHA community houses, of curtailing the amount of outdoor air brought in for ventilation purposes to as low as 5 cfm per person, discussion must center around the question of whether 5 cfm of outdoor air, per person, is adequate for ventilation in confined spaces intended for human occupancy.

The past researches and experiences of our Society seemed to show that there are minimum quantities of air supply to enclosed spaces below which it is not safe to go. The ASHVE ventilation standards, which are the standards today, based upon research and experience which proved at the time when they were adopted that not less than 10 cfm of outdoor air, per person, is required to maintain adequate standards of temperature, quality, air motion and distribution, and those 10 cfm are the minimum.

However, can we afford to depend too much on the past? Is our past experience to furnish the light for our path ahead? Sir Stafford Cripps, the War Cabinet member for Great Britain, stated recently that we are building up a vast store of knowledge for the purposes of war that we will use in the time of peace. It may be that the ventilation practices and changes that are now taking place in war projects will have an influence on our standards and our practices after the war. The degree to which practices in lowering the standard of minimum ventilation requirements affect health and efficiency of workmen will, of course, have great bearing on whether or not they will be continued after the war is over. What has brought about this demand today for a curtailment in the outdoor air supply? What is the reason for it? Is it entirely a question of economics? Of course we know a great many things are being done today in the interest of expediency, and properly so, because we must meet an emergency with emergency measures. But is this exactly an emergency?

No single standard will meet every need. Ventilation is more than a quantity of air. It is the maintenance of a quality that constitutes the environment. It includes temperature, humidity, air motion, freedom from odors and from bacteria, dust, and deleterious gases. The quantity to meet these requirements usually far exceeds the quantity required to maintain a supply of oxygen for metabolism purposes. So in some cases we find it is a problem entirely of engineering, rather than of physiology.

In working on designs for air raid shelters we can calculate accurately the air quality that will exist under any set of conditions, because then we are dealing with gas tight enclosures. In shops and factory buildings that are far from airtight, the uncertainties of infiltration always exist, making exact forecasts impossible. How much dependence can we place upon the unpredictable? How much should be according to rule? How much should be left to good common engineering sense?

Each member of this panel will give a short prepared statement of his views on this whole subject, following which we shall enter into a panel discussion, at the close of which the audience will be invited to participate.

I will now call for a statement from our panel member, Mr. Jones.

Mr. Jones: A good many years ago I had the privilege of attending a course in heating and ventilating under Professor Carpenter, who was then the Dean of Engineering at Cornell and a very eminent authority, and, I think, author of most of the early books. In one of his books he stated that good country air contained about 2 parts per million of carbon dioxide, and he advanced the theory that humans could live without ill effect in a concentration containing up to 7 or 8 parts, and from that he established what he called the standard of purity.

Now, with the knowledge that the average human exhales something like six-tenths of a cubic foot of carbon dioxide per hour, it was an easy matter to calculate the quantity of fresh air required to maintain a standard of purity, which he stated was 7 parts per million.

I believe that was the basis on which most of the earlier school codes were established, because it happened to work out about 30 cfm of fresh air per person. In Pennsylvania the code used to be 30 cu ft. In Ohio it was six changes, which, with the limitations on cubage, amounted to about the same thing. Since that time we have definitely established that human beings can live in far greater concentrations of carbon dioxide. In any building, where there is a reasonable cubage per person and some infiltration, I think the supply of oxygen can be entirely neglected. I see no reason why we could not safely go to complete recirculation without any mechanically-supplied fresh air, provided only that we can maintain proper temperature, humidity, and control of odors.

It seems to me, therefore, that this discussion resolves itself into the question: Can you maintain proper air conditions with as little as 5 cu ft per person? I am convinced in my own mind that at least in many of the so-called defense plants that is entirely impossible. I am thinking specifically of a plant that was built a short time ago in Cleveland, which has a cubic content of about 7 million feet and a population of perhaps 12 to 15 hundred. Incidentally, it is a windowless building. We figured the zero weather heat loss at about 6 million Btu per hour, and the internal heat load, including only lights, people, and power, at something over 9 million. The plant is ventilated with an atmospheric cooling system in which they supply almost 1¼ million cubic feet of air in summer, all of which is outside air, naturally. In winter that is cut to about 700,000 cu ft, and enough outside air is taken automatically to maintain a 70 deg temperature.

It was expected that in zero weather it would require about 65 deg entering temperature (10 to 15 per cent of outside air), to hold the temperature down. This would be equivalent to 45 cu ft per person. In actual practice the plant has been somewhat overloaded with both men and machines and we have found that in 30 deg weather it takes 55 deg entering temperature, which is about 37½ per cent outside air and provides about 75 cfm per person.

I am rather opposed to codes, on general principles, and I doubt very much if it is possible to set up a standard which is applicable to all such jobs.

Chairman Howatt: Mr. Lewis, will you give us your opinion?

Mr. Lewis: Mr. Referee, my remarks are directed toward ventilation only, rather than the total volume of air. I will deal specifically with that. In connection with it, I don't believe that we can sit here and draw any general rules of ventilation that will apply straight across the board to the question, "Will reduced outside air quantity undermine public health and efficiency?"

The reason is that in all buildings where people assemble for pleasure, commerce, or work, they foul their own air, or it is fouled for them to a greater or lesser degree; depending upon many different factors. There is no general rule of 10 cfm or any other volume which will apply to all. I have engineered plants in which 5 cfm was ample; others in which 50 cfm applied by conventional methods was entirely inadequate and still others in which the requirements of an industrial process would provide more than 250 cfm per person unless extreme measures were taken to make dampers abnormally tight.

Let's examine some of the factors which apply. There are cases in

which the very minimum of expected infiltration will give super-ventilation. There are buildings the cubic contents of which provide reservoirs, replenished 24 hours per day by infiltration and of such size that they will not be overly contaminated during normal period of occupancy. There are rooms in which 10 cfm is ample in one part, and entirely inadequate in another. There are buildings, particularly industrial plants, where satisfactory results can be obtained only by collecting contamination at the source.

In view of this, it is in order briefly to review progress.

There are still in existence codes which require the introduction of 30 cfm of outside air per person, and many installations made under the dictates of these codes are not operated even in normal times.

In the progress which we have started to make we have departed to some degree from thinking of ventilation as a percentage of the total volume of air; the total volume determined in large part by factors wholly unrelated to the requirements for ventilation. Thinking along those lines, however, is still being done.

We have largely departed from the criteria of determining ventilation by air change, regardless of the relation of the total space to the number of people in it.

We have determined the minimum volume of outside air for the individual, but we have set this up as a general rule without due allowance for the reservoir in which that individual is frequently living or working.

What should we do about this? First of all, I think we should develop more yardsticks, and improvements should be made in those now available. I think we should call for more cooperation and better coordination of all of the sciences which can contribute. I think we should avoid the overdoing which leads to the disuse of equipment which if more closely sized would not be abandoned on account of high operating cost.

I think we should drop the word *comfort* from our vocabulary and find one that adequately fits the application of our art to the conditioning of people and apply that with an intelligence equal to that which is applied to an inert substance in process in an industrial plant.

As to codes, perhaps Mr. Jones and I can get along without them but maybe we need them for you.

Dr. Winslow: Mr. Chairman, I am sorry to put you in an embarrassing situation. I may say that Mr. Howatt pleaded with us at breakfast this morning for a row—he wanted a scrap. But if he wanted that he should not have asked three different people from different parts of the country to prepare written statements beforehand. Since he did so, I think I shall have to present mine, which is essentially identical with the first two that you have heard.

The question whether the supply of outdoor air should be reduced from 10 cfm (or from 30 cfm) to 5 seems to me quite meaningless if the proposed standard is to include such occupied spaces as FHA homes and munitions plants of various types.

The present Society standard of 10 cfm is based on calculations which refer to an air-tight space in which such an amount of air is necessary in order to dilute body odors. Even in homes its application cannot be justified without consideration of many complicating factors.

The report of the Committee on the Hygiene of Housing of the American Public Health Association, which is probably the most authoritative document in this field has this to say on the matter:

"The odors given off from the body have been proved to exert a definitely harmful influence upon appetite and therefore upon health. With persons of reasonable cleanliness the dilution of these odors will require an air change of 10 cfm per person.

"Such an air change as this, with any ordinary type of construction, will be automatically attained in cold weather by normal leakage through walls and ceilings of ordinary porosity and around normally constructed doors and windows, provided the cubic space per occupant is 400 cu ft in any occupied room, and that the normal ratio of fenestration is supplied. The necessary air change can be secured in summer by the opening of windows. Since this minimum of 400 cu ft is demanded by other fundamental needs to be discussed in later sections, no other provision for air change need ordinarily be made in the low-rent dwelling. If the other fundamental needs could be met, and if dependable artificial ventilation were provided, a lesser air space might be permissible."

In the ordinary dwelling house, therefore, the factors of leakage are with ordinary building construction adequate to take care of a space which is not crowded. In an ordinary schoolroom window gravity ventilation supplying about 10 cfm of air has proved the most satisfactory method of handling the situation; but the supply of air must be accomplished by the use of properly designed heating appliances and deflectors for the admission of outside air so as to avoid unpleasant drafts. In a large auditorium with 50 or more persons nothing short of mechanical ventilation supplying 20 or 30 cfm of air will suffice, since the people in the center of the room are too far away from the windows to get the benefit of a gravity supply.

To apply any such standard to a factory workroom with 6000 cu ft per person and probably with open doors and skylights would obviously be fantastic so far as the problems arising from human occupancy are concerned. Clearly in such a space as this a supply of 5 cfm of outdoor air per person would constitute an altogether negligible factor from a quantitative standpoint, and would be nothing more than a meaningless gesture.

On the other hand if the industrial processes in question produce a large amount of heat or generate noxious fumes and dusts, it may be necessary to provide artificial ventilation far in excess of 5, 10, or 30 cfm.

It is easy, of course, to attempt to settle such matters as this by arbitrary rule-of-thumb methods, but such a procedure does not in any way correspond with the realities of the situation.

Chairman Howatt: Mr. Jones, is your fear of establishing codes merely that we may hang on to them when we should let go and let go when we should hang on? Are you afraid of them because of the time element?

Mr. Jones: When you establish a minimum code it is pretty likely to become a maximum. If we set an arbitrary figure of so many cubic feet of air per person, in many cases it may be more than is necessary, and in other cases insufficient. I think it would be far better if we could establish a code on the basis of quality. In other words, we might say that it would be necessary to provide a sufficient amount of air so that the temperature would be between certain limits and the purity would be within a certain standard. The difficulty, of course, is that that sort of yardstick is too hard to apply in the field. It is too difficult to make work.

Chairman Howatt: Is that your only objection to them?

Mr. Jones: Yes. I have no other objection.

Chairman Howatt: Don't the benefits outweigh those slight objections of yours? Weren't the codes primarily fostered with the idea of leveling out competition to some extent and getting rid of the chiselers in the industry?

Mr. Jones: Codes for that purpose have been set up by the industries themselves but I think primarily a legal code is set up for the protection and health of the people. Certainly that is the purpose of plumbing codes, for instance, and I don't know why it should not be the same purpose in ventilation.

Mr. Lewis: I have been thinking of certain new devices that are growing up to be tacked onto our air conditioning system. We get a light that kills bacteria and a device for collecting the products of flatulence and then comes the improvement of building construction, glass brick, and things of that sort to make buildings tighter. After a while, we may kill all the benign bacteria along with the malignant.

We should look forward to the time when infiltration, for which we should be more grateful than we are at times, is all cut off. Then we will need codes, but our codes should be realistic with respect to the ultimate results that we want to obtain.

A code that is based purely on the amount of outside air that is taken in without regard to where that air comes from, is really silly. There might be next door to your outside air intake some of the foulest contamination, or there might be products given off within the rooms which could not be diluted with ordinary ventilation, in any volume.

I think while we are perhaps fully justified in doing a little smiling at codes, it is nevertheless quite essential that we keep them around and nurse them along until we can make them realistic.

Chairman Howatt: What would the Health Department do without a code?

Mr. Lewis: What would we do without a Health Department?

Chairman Howatt: Very poorly.

Mr. Jones: I think that last remark was more to the point.

Dr. Winslow: I should like to reinforce what has been said by an analogy. I have no objection to codes, but I think they should be sensible. Suppose in a problem of heating you attempt to operate on the basis of supplying so many Btu per person per hour, irrespective of what hap-

pens outside or what happens inside or the conductance of the building? You don't do that. That is no sillier than it is to require 50 or 30 or 10 cfm without taking into account any of the conditions that are operative. It is an attempt by a shortcut to dodge a fundamental engineering problem.

Now, you take a contract to provide a certain temperature under certain external weather conditions in a particular building, and you work that out, and you determine how many Btu are needed. I think the same principle is the only one that will solve this question of air change.

Chairman Howatt: Dr. Winslow, when a contractor is dealing with the unpredictable, which in this case is an uncontrollable air supply, just how would he arrive at a bid to guarantee end performance?

Dr. Winslow: Just as he does in leakage. You can predict leakage. You can specify certain conditions of occupancy, obviously, just as you do in your heating.

Chairman Howatt: The heating load, of course, is determined by factors from our Guide, based on a certain anticipated amount of infiltration. You set up for a peak load condition then, a condition under the worst that will arise.

Dr. Winslow: Assuming that temperature is taken care of, but with no other problem except avoiding the accumulation of objectionable odors from the human body, you need 10 cfm per person of air change, but you ought to allow for presumable leakage and, what is much more important, on the other side you have got to allow for other sources of odor, for smells from cooking and for excess heat produced and for fumes and so forth. The engineer cannot dodge his responsibility of studying the particular building that he is working on and deciding on the basis of his best judgment what is needed.

Chairman Howatt: When an engineer cannot do the engineering himself he specifies that the contractor or the manufacturer shall maintain certain results. That is an old game. Those are *murder* clauses still found in many specifications. Well, are you in favor of that kind of *out* for engineers who are afraid to take the responsibility for the solution of their problems?

Dr. Winslow: No. I think the engineer has got to exercise professional judgment—not the contractor; but I don't think anyone but the engineer can deal with such situations as Mr. Jones has mentioned. It has got to come back to the wisdom and experience of the designer.

Chairman Howatt: Well, then the designer has to set up the air quantities, not the results.

Dr. Winslow: Well, he sets up the air quantities on the basis of the results to be obtained, just as you set up your design for heating on the basis that you want to maintain, say, a 70-deg temperature.

Chairman Howatt: Speaking not as an officer of the Society, Doctor, but as a well versed member, the Society has several code committees working on codes and on adjustments of codes at this time. Are you in favor of the elimination of all of our codes and the discharge of all of these committees?

Dr. Winslow: As far as I know, most of the codes operate on the basis I have been speaking about. I have no attack to make on codes. Most of the codes specify the type of construction which will attain certain results.

Chairman Howatt: They are dealing with unpredictables, are they not? In my opinion, the real objection to a code is that the thing lasts too long. It generally outlives its usefulness long before it is thrown out and, because it outlives its usefulness, to that extent it does hinder progress. That is my main objection to codes. They stay and they stay in our thinking and our practice long after they have ceased to be useful. Look how long that 30 cfm per pupil stayed in schoolhouses.

Dr. Winslow: It is still there.

Mr. Lewis: After a while the code just stops you from thinking.

Chairman Howatt: Now, Dr. Winslow, you are known as an authority on physiological reactions of the human system to its environment, a health officer who can advise the Society and guide it in the ways of health. There are three phases of ventilation problems: one is health, another is efficiency of the workman, and the other is comfort. In total war we know that it is essential that a worker producing food or munitions of war must receive the same care that a soldier does on the battlefield, if the wastage of our manpower is to be prevented. How important the health of the people is to the welfare of a nation is indicated by the principles laid down in the Four Freedoms, two of which, freedom from fear and freedom from want, are definitely important health factors. Of course, health cannot be measured like the pressure on a steam gage, but there are certain indices that can be used to determine health, determine disease, and there are tables of mortality. They do not tell us exactly what caused the sickness or the death but they do give us material on which we can think about those problems. Dr. Winslow, will you tell us what you think about the health phase of ventilation?

Dr. Winslow: Well, I think perhaps the best answer to that is to point to the winter prevalence of respiratory diseases. It is the most interesting and important fact in epidemiology. Why do we have colds and pneumonia and influenza in winter and not in summer? That is a problem of air conditioning. There is no other reasonable explanation of it. I think that is an illustration of the very important effect on health of too great shocks from the temperature angle. You get just the same thing in certain industries. I hope there are no reporters present who can misconstrue this, but you get the same excess death rate from pneumonia among workers in blast furnaces (in places other than Pittsburgh, let us say) who are supposed to be exposed to sharp contrasts between heat and cold.

You mentioned efficiency. Some of our best knowledge of the relation of temperature to efficiency grew out of the English studies during the last war, when they showed beyond question the direct effect on production, the very important effect on production of the maintenance of proper temperature in the workrooms.

Chairman Howatt: Now, you see, Doctor, it is easy for us to say *ventilation* and *proper air environment* are so important to health. Isn't health a very difficult thing to measure, and does it not take a long time before any influence is noticed from an air environment on the health of the people? Have we been emphasizing too much the importance of ventilation on public health?

Dr. Winslow: Well, I think not too long to be measurable in a great many ways.

Chairman Howatt: The other factor that is involved in this question is the factor of comfort, the air environment with relation to comfort. Mr. Lewis said he wished the word *comfort* had been left out of our vocabulary. Don't you feel comfortable today? Why don't you like the word *comfort?*

Mr. Lewis: Well, I don't like it because it casts a fog around, or a halo over the true objective. I believe that one of the great misfortunes of our profession and industry is the almost universal use of the word *comfort* to describe either the objective or the results of air conditioning or ventilating or heating. This misfortune applies not only to those who make their living out of the industry, but also to those who should benefit from the use of our services and products.

No one can justly single out anyone to be blamed for this because it just grew and no one could foresee the outcome. Our Society created a comfort zone on a chart. Hundreds of individuals have applied the word *comfort* thousands of times. I know only one who has tried to lead us away from its use—Charlie Leopold.

The upshot of it all is that we have held the spotlight on the erroneous conception that the prime and perhaps the only function—particularly of air conditioning—is to provide rocking-chair comfort.

This false concept has too completely obscured the real objective of raising the quantity and the quality of the production of human beings. It has led to a misguided condemnation by high authorities which have added many difficulties to getting done those things which are essential to the quantity and quality of essential war production.

Let's bound the field with a few typical examples.

Many vital parts of bombsights, aircraft instruments, radio, radar and the like are made of non-ferrous metals. On these precision parts, the finger print deposits of skin excretion frequently become the seed from which corrosion may grow when the part is exposed to an environment favorable thereto—a growth which, without any warning, impairs or destroys the usefulness of the part.

The quantity of skin excretion—not visible enough to be called perspiration—is increased or diminished by environmental air conditions. The objective in conditioning these production plants is simple, sound and obvious and is not to be confused with or obstructed by any thought of rocking-chair comfort.

In conditioning a bank, the real

objective is to reduce the cost of doing a banking business. It is accomplished by providing an environment which will reduce the number of errors, increase the production of the individual and lessen turnover through improved customer employee relationships.

The bank can measure production in terms of items per employee and can get its answer in a black ink balance sheet, expressed in dollars and without regard to units of rocking-chair comfort.

The objective in reducing the gaseous and particular contamination in a welding shop is to increase production and improve the quality of the product—and, of course, health.

Although it is definitely out for the duration—applying complete air conditioning to the home comes close to the rocking chair but the analytical thinker will look beyond it to two ultimate objectives, hastening recuperation from the day's fatigue and rebuilding reserve capacity for the next day's production.

Dozens of examples can be cited but these four cross the field from the four points of the compass.

No, our ultimate objective is not comfort. It is to give man or woman a fair chance to apply the fundamental of creating wealth by producing up to the limit of his latent capacity.

In working toward this objective, there are two channels of design. One is just to condition the space—the other is to condition the human being who works in that space. The first is shortsighted for provided we give the individual human being good air to breathe—what does it matter if environment 10 ft away is not good—provided we sweep away his animal heat at a commensurate rate—and provided we protect him from the heat or from the cold of his environment.

We could do better if we would alter our fundamental thinking, find a new and appropriate word to define our objective and adjust our practice accordingly.

Chairman Howatt: These are certainly new ideas. The panel at least is not in a groove throughout on codes or on the word comfort. As far as I am concerned, it seems to me if I am too comfortable I get lazy. The third step in the need for a proper air environment, Jones, I am going to ask you to discuss a bit, and that is what effect it has on the output of workmen, the so-called efficiency of the plant or the man, and what relation does it have to some other factors that you may have in mind

Mr. Jones: I have a pretty strong conviction in my own mind that health and this word that Lewis does not like, *comfort*, and efficiency, are all pretty much wrapped up with each other. That is, I have a notion that an atmosphere which is comfortable is also healthful, and probably promotes efficiency. Although unfortunately, there is to my knowledge not much statistical data on the subject of efficiency of workers, I still believe it is a real thing.

I know of one example—an inspection department of a plant which was made up largely of girls—which was moved from a very poorly heated and usually overheated, unventilated, inadequately lighted room into a brand new, air conditioned space, with an illumination of about 50 foot-candles on the working table.

Immediately, the number of pieces of material that passed over those desks increased about 60 per cent. It is quite obvious that some of the improvement could be charged to air conditioning, but how much is chargeable to air conditioning, how much to better light and how much to the simple fact that they might have had a lot of work to do in a hurry, is hard to say.

Incidentally, that question of efficiency is one which is important to those of us who make a living, or at least a part of a living, by designing or selling or installing air conditioning equipment, because it creates a very handsome yardstick to measure the value of a set of equipment to an industrial plant. I wish that we had more information on the subject, because it would be a fine sales talk.

Chairman Howatt: Do you want to challenge him in any way, Dr. Winslow?

Dr. Winslow: No. I think I am entirely in agreement with the concordance of comfort, health and efficiency. Take one illustration. We used to talk a good deal about 68 deg as the ideal temperature, without very much basis for it, because there had not been very much work done. You will remember the Society carried on some very extensive studies in factories and found that in some of them the workers lightly clothed and doing light work preferred a temperature of about 72 deg. Very careful studies in the Laboratory have shown that that temperature of 72 deg for a person lightly clothed and doing light work, or no work, was just the temperature at which the body was in equilibrium, without having to produce extra heat to give to the environment and without having to produce sweat for an extra cooling effect. I feel very sure that these problems of health and comfort and efficiency are very closely related, and on the efficiency side, as I say, there hasn't been much done in this country, but Vernon in England accumulated a lot of data, very good data, in which nothing was varied but the temperature of the factory air and in which he got very important effects on production—very material increases in production by preventing in that case overheating.

Chairman Howatt: The panel discussion is now open for general comments.

C. S. Leopold, Philadelphia, Pa.: I have two questions. First, on the question of code. I believe, Mr. Moderator, that the thing to which most of us object is being told how to do it instead of being told of the result we are to obtain. Unfortunately, I think that we will have to admit that, at this moment, we are not too sure of the result we are trying to obtain and therefore temporarily we have certain codes which are based on method. I think that is the basis of our objection to codes—we don't want to be told how.

The second point: In the preceding discussion I have noticed that the introduction of fresh air has been made synonymous with the reduction of odor. Actually, the factor of relative humidity is almost of equal importance—it certainly is of comparable magnitude. We are all familiar with the fact that if you permit relative humidity to get appreciably above 50 per cent, you have a musty odor regardless of fresh air quantity used. I wonder if Mr. Oscar Levant Lewis would like to speak on this point?

Mr. Lewis: The particular experience was with a building in San Antonio, Texas, a 20-story office building. It had quite an outside air intake but was designed for a graduated amount of outside air. After a couple of years of very successful operation we began to get complaints about odors, odors of linoleum, odors of paint and books and various other things, coming from all over the building. We sent three different men down to diagnose the trouble and prescribe the remedy. They all came back licked. Finally we tried another one. This fellow had primed himself pretty well. He knew what dew point and what temperature and what relative humidity was supposed to be carried in the building. He discovered that during the intermediate season, in an attempt to get rid of odors, the outside air damper control had been disconnected and the dampers blocked wide open, so instead of getting 5 or 10 cfm per person in that building we were getting 40 or 50, and still we had the odors around. The remedy was to put the dampers back under control, to reduce the outside air quantity down to a relatively insignificant amount in relation to what had been taken in and to get the dew point and the relative humidity down.

W. L. Fleisher, New York, N. Y.: I don't agree with your panel. In the first place, I think that a code is more than essential. Make it as minimum as you like, but Mr. Lewis is talking here from the light of his 50 years of work in this business and consequently he knows a great deal more than does the average person who has to qualify in various parts of this country and who needs a code.

Now, because of the fact that 30 cu ft of air per person had been used for so many years as the amount of air required for school ventilation and because it was so criticized in the light of our later knowledge, the State of New York voided this law and passed a new law. I was called in by some of the interested parties to fight the proposed law, which simply specified that the Director of Public Education of the State of New York should determine what was required for proper ventilation of schools. Certainly 10 cu ft of air, which we tried to have introduced into the code as a minimum, would have been infinitely better than no stated amount, and the amount to be used could have been raised above 10 cu ft but could not have been reduced below that.

After all, the reduction of ⅔ in the amount of fresh air required was going a long way towards correcting an obvious fault. The 10 cu ft had been determined by a group of engineers as being a good minimum and about what was essential. Remember that when you are dealing with the public you are dealing not with engineers, but with people who think

they have a good bit of knowledge about a subject and don't require the services of an engineer. It is well to hold those people to a minimum as long as the minimum within our knowledge is not excessive. I am all in favor of codes as long as they are not extravagant in their demands.

Mr. Lewis seemingly has completely gotten off the subject of this forum. As far as the comfort zone or the comfort requirements as developed by the Society are concerned, in my opinion they have had more to do with maintaining the prestige of air conditioning and increasing your business than any other one thing in the whole range of engineering. These developments of the Society have made the public realize that there are certain conditions which are comfortable, and these conditions have been demonstrated by the Society over and over again to the point where the public believes in them. The work of the Society has also definitely indicated that beyond a certain point no one is comfortable and consequently a code within the range indicated is a safe and constructive code or standard to apply and to publish.

Mr. Chester: I do not intend to attack the entire panel because collectively they seem fairly formidable and all of the same mind. I just propose to pick on Mr. Lewis. I am surprised to find that he confuses comfort with ease. When a man is sitting relaxed in an armchair, his state is one of ease and not necessarily of comfort; as it may be too hot or too cold for comfort. Human comfort is the fundamental objective of this Society, the aim being to provide a condition as regards air temperature, air movement, vapor pressure and mean radiant temperature which closely approaches the ideal. I see no reason for scrapping the word *comfort* as it is certainly expressive and I suspect that Mr. Lewis is just amusing himself in suggesting it. In the sense that we use the word comfort, it pertains to disposal of the heat which must be lost by the body, without any consciousness of heat or cold or of perspiration; in other words with no discomfort. With suitable atmospheric conditions energy is increased. An individual can be numbed with cold or weakened by heat. In hot countries people refrain from working in the hottest part of the day; they take siestas.

With Dr. Winslow present I do not feel like saying much about physiological matters but it is now common knowledge that in too hot an environment too much blood goes into the sublayers of the skin in an effort to lose heat and not enough to the vital organs.

I favor keeping the word comfort in our vocabulary.

L. T. Avery, Cleveland, Ohio: If you are going to talk about the quantity of air as being the ventilating system operation, that is, 10 cu ft, or 5, or 30, I don't think it has anything to do with operation. If there is one thing that causes odors, that would make a place distasteful from a working comfort standpoint, it is the stink—and stink has more to do with cleanliness of the apparatus than it does with the quantity of outside air. Nothing in our standards provides any means at all for regulating how often this equipment should be cleaned, or what is clean air. So if we are going to standardize, and say 5 or 10 or 30 cu ft and be silent on the rest of it, we have missed the boat. I for one don't think we are undermining public health and efficiency and it will be too bad to let either subject drop without getting that pretty clear that we are not undermining anything; we are simply neglecting ordinary housekeeping.

Chairman Howatt: Are there any other questions from the audience?

H. M. Hart, Chicago, Ill.: I can't agree that we should abandon codes. We worked a long time in Chicago trying to write a city code for ventilation, and I was on the committee. We tried to incorporate in the city code the American Society of Heating and Ventilating Engineers' Code which specified the results to be obtained but the authorities and the Health Department said that they could not administer it. They were so violently opposed to it that the only thing they would consent to do would be to try to calculate the volume of air that would be necessary to produce the desired results for different types of buildings, and put that in as the code required. The committee of engineers who helped to formulate the code did not agree with this procedure, but from an administrative standpoint we had to back down. I must admit that I don't know how they could administer it. The administrator would certainly have gotten into a lot of trouble if the code simply provided for certain results to be obtained and after the building was erected the system failed; it would mean that he would have to condemn the building and have it torn down and built over again. I don't think he would have lasted very long under those conditions. That was our difficulty. And so we concluded that the only way out was to try to calculate the minimum air quantity that would be required to maintain the conditions that they hoped to obtain.

Mr. Lewis: In regard to this business of comfort—an ideal working environment is not one in which you are conscious of being comfortable. It is one, to borrow from Charlie Leopold, in which you are wholly unconscious of temperature, humidity, air motion, or anything else. You are not annoyed by anything plus or minus.

As to codes, I think you might as well leave out of the record everything that has been said and print Charlie Leopold's remarks about codes in big capital letters; that they should not tell us how to do something, but should tell us what upper limits must not be exceeded. The how-to-do-it should not be frozen into a code.

Dr. Winslow: Before closing I want to enter a protest against the unfair tactics of the Chairman. He selected the title of this symposium and then he wrote to each one of us and asked us to talk about 5 cfm, which, quite justly, had nothing to do with the title and then, when we presented ourselves here with a touching and beautiful magnanimity he misrepresented us, tried to make it appear that we wanted to be uncomfortable, that we were opposed to all codes, and that is manifestly unfair. Then the final error he made was in not having Mr. Leopold on the panel, because I agree with Mr. Lewis that Mr. Leopold said the one really vital thing, that codes should deal with the results to be produced, and not with the methods.

Chairman Howatt: Just to correct the worthy gentleman on my left, the Chairman or the Moderator had nothing to do with the subject at hand. It was selected by the Meetings Committee of the Pittsburgh Chapter. Neither had I anything to do with the panel selection, and if I had, I would have chosen the same panel.

It is evident to all of you, after listening to this panel discussion, that there can be no such thing as a hard-and-fast rule about how much air shall be recirculated per person, or how much of that air shall come from out of doors, in order to provide what is now called an ideal inside climate; 5, 10, 20, 50 cfm, any one of them may be wrong at some time. The quantity required depends on so many factors that every building should be considered as a problem by itself, studied with relation to the building construction, the kind and the type of work that will be carried on in the space. It is evident that the one-third cubic feet of air needed per minute per person to provide the oxygen required for breathing is indeed a negligible factor and need not be considered in any of these engineering problems. We use the air merely as a distribution medium to obtain results, and the amount of air that is going to be required or circulated will depend entirely upon how fast the desired conditions are broken down within the building. The decisions finally arrived at should follow an intelligent study by competent, trained, experienced engineers. So to ask if 5 cfm is enough is like asking a man if he would stop beating his wife. The question cannot be answered by yes or no.

At the conclusion of the panel discussion President Blankin expressed the appreciation of the Society to members of the Panel for a most interesting and instructive session.

The chairman of the Resolutions Committee, H. H. Erickson, Philadelphia, then gave his report as follows:

Report of Committee on Resolutions

Whereas, the Semi-Annual Meeting 1943 of the American Society of Heating and Ventilating Engineers has been an outstanding event in the City of Pittsburgh, June 6 to 8, 1943.

Therefore, Be it Resolved, That an expression of thanks and appreciation be adopted by this meeting and be spread upon the minutes of the Society and copies thereof be transmitted to each of the persons and agencies who have contributed to making this meeting so enjoyable for the members of the Society who attended:

To G. G. Waters, President of the Pittsburgh Chapter and the Chapter Members for the capable manner in which they fulfilled their positions as hosts,

To Chairman Ralph B. Stanger and the Committee on Arrangements whose careful planning has been shown in every detail of this meeting,

To Mrs. T. F. Rockwell and her Committee who under trying war conditions were able to do such splendid work in entertaining the ladies,

To Frank L. Duggan, President of the Pittsburgh Chamber of Commerce for his address of welcome to Pittsburgh,

To the Authors and Panel Speakers at technical sessions for their instructive papers and able presentations,

To the newspapers and trade publications whose columns have given advance notices and daily coverage to the Semi-Annual Meeting,

To Howard Coonley, Director, Conservation Division, War Production Board, for his interesting analysis of the Fuel Conservation problem,

To the Management and all employees of the William Penn Hotel who contributed much to the success of the meeting and comfort of the members under the difficult war circumstances,

To Fabian C. McIntosh, Chairman and the Hospitality Committee for their splendid contribution to the success and enjoyment of this meeting,

To the Pittsburgh Convention and Tourist Bureau for their cooperation and assistance,

To the nine Past Presidents for their continued interest and attendance at this meeting,

To Dr. Allen A. Stockdale for his inspiring address,

To the members of the Society who are in the armed forces and others who are giving their services in many ways, for the successful prosecution of the war.

Finally, to every member of the American Society of Heating and Ventilating Engineers who has attended this meeting for his loyalty and support.

Respectfully submitted,

H. H. Erickson, *Chairman*
M. W. Bishop
M. B. Shea

On motion of Mr. Erickson, seconded by L. T. Avery the report of the Committee was unanimously adopted.

As there was no unfinished business nor any new business the meeting was adjourned at 4:15 p.m.

Entertainment

For those who arrived in Pittsburgh on Sunday, June 6, the Hospitality Committee of Pittsburgh Chapter greeted the members and ladies for their entertainment. The ladies guided by the Ladies Committee and hotel staff enjoyed a tour of inspection of the William Penn Hotel, at 4:00 p.m. They viewed the kitchen while a meal was in preparation and saw the refrigerators, the wine cellars, linen rooms and many other interesting sights. At 6:00 p.m. there was a reception for visiting members and ladies in the Cardinal room of the William Penn, which provided an enjoyable social hour and a buffet supper.

The Ladies Committee in charge of Mrs. Theo. F. Rockwell, welcomed the visiting ladies and entertained them at tea at 3:00 p.m. on Monday afternoon.

After the all-day technical sessions and various committee meetings, the entertainment committee with H. E. Park as chairman, arranged an informal get-together at the Nixon Restaurant, where the members enjoyed a mid-night supper and floor show.

For the concluding event, as a fitting climax to the very interesting meeting, an informal dinner was held in the Urban room of the William Penn, and E. C. Smyers was chairman of the Committee in charge. During the dinner an orchestra played musical selections and the Television Kids from Station KDKA gave a demonstration of modern and classical music. At the conclusion of dinner Toastmaster F. C. McIntosh introduced the distinguished guests and the nine Past Presidents of the Society who were in attendance. He then called upon Pres. M. F. Blankin to present a resolution to John James, former technical secretary of the Society.

The Past President's Memory Book was presented to Prof. E. O. Eastwood of Seattle by President Blankin. In a brief speech which reviewed the professional accomplishments and services rendered to the Society by Professor Eastwood as President, F. E. Giesecke, Past President, presented him with the Past President's Emblem of the Society.

The speaker of the evening, Dr. Allen A. Stockdale, New York, was introduced by Mr. McIntosh, and speaking on the subject "Democracy Can Do It," Dr. Stockdale gave an inspiring message which was greeted with frequent applause by the audience. He described the tremendous output of industry, the collossal tonnage of shipping, guns, tanks, ammunition, airplanes, trucks, and other implements of war. He contrasted the fundamental beliefs of our democracy with those of the peoples in the dictator dominated countries, and brought out the fact that we had freedom of action, speech, and many other privileges, that our army had an unselfish objective and was not actuated by the ambitions of a conqueror. It was a stirring address that gave the audience many facts to demonstrate that only in a Democracy could the cooperation and the will to win, wield the people into a unit that would overcome all obstacles.

Rules for Reinstatement*

Art. R-III, Sec. 4—When a resigned member of the Society desires readmission, he shall address his request in writing to the Secretary of the Society. The Secretary shall mail to each member of the Council a statement which includes the name of the applicant for readmission, the period of membership and the grade previously held. The Secretary shall notify the applicant in writing of his reinstatement which will become effective upon payment of dues. The name of the applicant shall be published in the next issue of the Journal and a membership certificate shall be issued by the Secretary.

Section 5—Anyone whose membership in the Society was cancelled for non-payment of dues (Art. B-11, Sec. 2) may apply for readmission to the Society by addressing a request for reinstatement to the Secretary of the Society. This request shall be accompanied by remittance for reinstatement fee in the sum specified by the Council. The Secretary shall notify each member of the Council of the name, period of membership, and the grade previously held by the applicant. The Secretary shall notify the applicant in writing of his reinstatement. The name of the applicant shall be published in the next issue of the Journal and a membership certificate shall be issued by the Secretary.

Section 6—When an applicant's age makes him or her ineligible for reinstatement as a Student or Junior Member, he or she will automatically be entitled to Junior or Associate Member grade per Art. C-II, Secs. 5 and 6.

When advancement is requested, application shall be made on the regular form and the Secretary shall send it to the Admission and Advancement Committee for recommendation to Council.

Section 7—A candidate for readmission into the Society shall be reinstated without reduction in grade.

*Adopted by Council, June, 1943.

NDHA Honors J. H. Walker

At the 34th Annual Banquet of the National District Heating Association, J. H. Walker, Detroit, was elected an Honorary Member of the Association and toastmaster L. S. Phillips presented the certificate and read many fine tributes from Mr. Walker's friends in the industry.

Inscription on Certificate

It is our privilege to honor a man whose achievements and contributions in his chosen field are beyond ordinary measure.

With a gift for friendship, with gentle and unassuming personal qualities that have endeared him to every member of this organization,

J. H. WALKER

has given freely of his time and talents, has been generous with help and wise with counsel. To accord him a well-deserved tribute,

THE NATIONAL DISTRICT HEATING ASSOCIATION

by unanimous ballot has elected him an

HONORARY MEMBER

His able advice, keen judgment, and executive ability have been of inestimable value and his efforts have always been devoted to the best interests of the organization.

The highest honor in our power to bestow must be judged small recognition for his achievements. In the warm affection and esteem of all who know him will be found a true measure of his worth.

W. A. Herr, *President*
Leonard S. Phillips, *Exec. Committee*

Julius J. Schenk, *Vice-President*
John F. Malone, *Exec. Committee*

John M. Arthur, *Vice-President*
R. M. McQuitty, *Exec. Committee*

S. S. Sanford, *Vice-President*
John F. Collins, Jr., *Sec'y-Treas.*

BUY WAR BONDS AND STAMPS

ASHVE 50TH ANNIVERSARY MEETING ANNOUNCED

The selection of New York City for the 50th Anniversary Meeting of the American Society of Heating and Ventilating Engineers is announced by Pres. M. F. Blankin, Philadelphia, Pa. The dates chosen by the Council at its June Meeting are January 31, February 1 and 2, 1944.

The New York Chapter of the Society will be hosts for the occasion and arrangements for the meeting will be handled by a special committee of which Alfred J. Offner, consulting engineer, is General Chairman. Vice-Chairmen are: R. H. Carpenter, J. C. Fitts, W. E. Heibel, C. S. Koehler, Capt. A. E. Stacey, Jr., and R. A. Wasson, President of New York Chapter, Ex-Officio.

The Chairmen of the Committees in charge of the special events are as follows: Alfred Engle, Banquet; H. S. Wheller, Hospitality; W. M. Heebner, Finance; A. C. Buensod, Entertainment; Mr. and Mrs. H. J. Ryan, Ladies; C. S. Pabst, Inspection and Transportation; and R. V. Sawhill, Publicity.

The first Annual Meeting of the Society was held in New York City, January 22 to 24, 1895, and 75 Charter members had enrolled. The organization of the Society was first discussed in the summer of 1894 and a preliminary get-together was held August 2, 1894, in the World Building at which time the procedure for forming the Society was discussed.

The Organization Committee consisted of Messrs. F. P. Smith, H. J. Barron, J. A. Harding, William Mackay, A. A. Cary, and was authorized to form an organization of heating and ventilating engineers. The first meeting was held September 10, 1894, at the Broadway Central Hotel and the roll call indicated that 75 Charter members had been enrolled.

The Constitution and By-Laws were adopted and it was voted that the name of the Society should be the American Society of Heating and Ventilating Engineers. An election of officers was held and those selected, held office until the first Annual Meeting in January 1895.

A program that will provide a fitting tribute to the founders of the Society will be developed by the Committee on Arrangements, according to the statement of Mr. Offner, who emphasizes the point that the Society has had, "a great past and has a greater future."

MICHIGAN MEMBERS ADVISE RATIONING BOARDS

A series of meetings sponsored by OPA to inform local rationing boards of the new rules for fuel oil rationing has been held in a number of cities throughout the United States.

The Detroit office of OPA held meetings on June 2 and 4 for its rationing board members.

These Boards have been working in close cooperation with the Michigan Chapter of the Society and Pres. S. S. Sanford reports that engineers have been assigned to all of the rationing boards in Detroit and vicinity from among the Chapter membership.

The list of advisers assisting local rationing boards in Detroit and vicinity are as follows:

	Board No.	Name
Detroit	82-1	H. H. Hughson
"	82-2	G. H. Tuttle
"	82-4	R. H. Oberschulte
"	82-6	F. J. Feely
"	82-8	H. M. Keyser
"	82-10	R. C. Champlin
"	82-13	E. W. Bottum
"	82-15	D. J. Luty
"	82-17	Frank Marzolf
"	82-19	W. C. Smith
"	82-21	G. D. Winans
"	82-24	J. B. McCrea
"	82-26	James Beattie
"	82-28	E. B. Root
"	82-1	Charles Strand
"	82-3	H. J. Taylor
"	82-5	T. H. Mabley
"	82-7	F. R. Bishop
"	82-9	J. S. Kilner
"	82-12	W. G. Boales
"	82-14	W. C. Randall
"	82-16	W. F. Tydings
"	82-18	R. D. Randall
"	82-20	J. W. Bassett
"	82-23	R. L. Deppman
"	82-25	A. E. Knibb
"	82-27	Herbert Busse
"	82-29	R. F. Connell
"	82-30	J. N. Livermore
"	82-31	C. F. Donohue
"	82-32	L. A. Burch
"	82-33	L. K. McGaul
"	82-35	W. J. Whelan
"	82-36	E. H. Clark
"	82-38	E. E. Dubry
Royal Oak		R. L. Partlan
Birmingham		W. H. Old
Ferndale		C. W. Mally

McCORMACK JOINS FOX MUNITIONS

Denis McCormack, who for the past 11 years has been Manager of the Commercial Instruments and Controls and of the Flight Instruments Departments of Julien P. Friez and Sons, Division of Bendix Aviation Corp., Baltimore, Md., is leaving the service of that company July 1 to take up a more responsible appointment as General Manager of the Fox Munitions Corp., 21st and Arch St., Philadelphia, Pa.

Mr. McCormack is known as an authority on humidity measurement and control. He has been a member of the American Society of Heating and Ventilating Engineers for many years and also holds membership in the National Electrical Manufacturers Association and the Scientific Apparatus Makers of America.

N. Y. CHAPTER HOLDS SUMMER MEETING

The second annual summer event of the New York Chapter ASHVE was held on Thursday afternoon and evening, June 17, at the Plandome Golf Club, Plandome, L. I., with 53 present.

Some of the members and their guests took advantage of the splendid golf course and played the 18 holes.

Bob Wasson, the new Chapter President, introduced to the group Alfred J. Offner, General Chairman for the 50th Anniversary program, to be held in New York during January, 1944.

MARTIN TO ENTER CONSULTING FIELD

George W. Martin, Supervising Engineer for the United States Realty and Improvement Co., New York, N. Y., and its subsidiaries resigned effective May 31. Mr. Martin, an alumnus of Stevens Institute of Technology, was Chairman of the Research Committee, Management Division, Real Estate Board of New York and is a member of the American Society of Mechanical Engineers, a Life Member of the American Society of Heating and Ventilating Engineers and a Past President of the National District Heating Association. He plans to open an office as consulting engineer in the real estate field.

COMMERCIAL STANDARD

The U. S. Department of Commerce, National Bureau of Standards has issued, in printed form, Commercial Standard (Emergency) CS(E) 107-43 for Commercial Electric Refrigerator Condensing Units. Copies may be obtained from the Government Printing Office, Washington, D. C., at ten cents a copy.

SUMMARY OF LOCAL CHAPTER MEETINGS

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
Western Michigan	May 27	Annual Meeting—Boat and Canoe Club, Grand Rapids.	None.	Chicken dinner; games and contests (entertainment all home talent). Officers elected: Pres., C. H. Pesterfield; Vice-Pres., H. D. Bratt; Sec'y, V. H. Hill; Treas., Frank Harbin, Jr. Board of Governors: S. J. Dempsey, J. W. Miller, F. C. Warren.	63	1.20
Massachusetts	May 18	Post-War Homes Must Be Designed for Human Comfort.	J. E. Haines.	J. F. Tuttle was presented with Life Membership certificate in Society and was elected to Life Membership in Chapter.	60	Joint Meeting with ASRE
Michigan	May 18	Annual Meeting—Lone Pine Inn. Golf Tournament — Plum Hollow Golf Club.		Movies: The Flag Speaks; Road South; Timber Harvest; Michigan Moose.	62	0.63

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
Philadelphia	May 18	Annual Golf Outing and Dinner.		Installation of Officers.	53	0.43
Montreal	May 17	Canadian Vickers Inspection trip.	None.	None.	30	0.49
New York	May 17	The Engineer's Part in the 1943-44 Fuel Oil Conversion Program. Talk dealt with present and future situation of heavy fuel oil.	A. B. Wally, Chief Engr., Fuel Oils Section, Petroleum Administration for War.	Acceptance of By-Laws for new constitution with recommendations of Council. Alfred J. Offner was appointed General Chairman for Annual Meeting in New York in January, 1944.	48	0.34
Southern California	May 17	The Society's Activities in Wartime.	Pres. M. F. Blankin, Philadelphia, Pa.	Election of Officers.	37	0.29
Wisconsin	May 17	Control Problems	W. R. Miller	Election of Officers: Pres., F. W. Goldsmith; Vice-Pres., I. J. Haus; Sec'y., E. W. Gifford; Treas., O. A. Trostel. Board of Governors: A. S. Krenz, H. W. Schreiber, J. H. Volk.	38	0.50
Kansas City	May 14	Direct-Fired Heating Units and Dehydration.	B. B. Reilly, Pittsburgh, Pa.	Pres. M. M. Rivard discussed co-operation of Chapter with War Service Committee on Fuel Rationing. E. K. Campbell reported on activities of Chapter on fuel rationing and on membership.	27	0.41
Nebraska	May 12	The Society's Activities in Wartime.	Pres. M. F. Blankin, Philadelphia, Pa.	Dinner at Hotel Regis, Omaha.	20	0.40
Iowa	May 11	Movies: Effect of Draft on Stoker Fires; Effect of Stoker Air-Setting on Fuel Economy; Building a Bomber; Building a Tank.	Gene Olson, Asst. Prof. Extension Dept. Mech. Engrg., Iowa State College.	Election of Officers: Pres., C. H. Helstrom; Vice-Pres., W. W. Stuart; Sec'y-Treas., B. E. Landes. Board of Governors: L. I. Norton, R. K. Smith.	10	0.4
	April 16	Society's Activities in War-time.	Pres. M. F. Blankin, Philadelphia, Pa.		13	0.44
Pittsburgh	May 10	Annual Social Meeting—Architectural Club.		Election of Officers: Pres., G. G. Waters; Vice-Pres., T. F. Rockwell; Treas., L. S. Maehling; Sec'y., E. H. Riesmeyer, Jr. Board of Governors: C. M. Humphreys, D. W. Loucks, A. F. Nass. Movies—Mac, the Magician.	35	0.53

*The attendance ratios shown represent the meeting attendance divided by the Chapter membership. These will be useful as a partial indication of interest shown by local chapter members in various types of subjects programmed by other local chapters, and may be helpful in deciding on subjects for other chapter meetings.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 36 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by July 15, 1943, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ANDERSON, GRANVILLE W., Service Engr., Koppers Coal Div., Detroit, Mich.	*C. C. Russell C. E. Shaffer	*Walter Knox *G. V. McGurl
ANWAY, H. WILBUR, Research Physicist, Wood Conversion Co., Cloquet, Minn.	R. E. Backstrom D. B. Anderson	R. C. Jordan *C. C. Heritage
BELLMAN, J. V., Engineer, Sales Engineering (Canada), Limited, Toronto, Ont., Canada.	V. J. Jenkinson *T. Charles Agnew	S. A. Jennings R. S. Mathison
BORNSTEIN, WILLIAM, Htg. Contractor, Wm. Bornstein & Son, Washington, D. C. *(Advancement)*	M. S. Hall W. E. Kingswell	A. B. Bornstein Glegge Thomas
BRANDT, FRED C., Engr., Minneapolis-Honeywell Regulator Co., Houston, Texas.	D. S. Cooper A. F. Barnes	J. A. Walsh A. M. Chase, Jr.
CHATFIELD, ARTHUR J., Htg. & Vtg. Engr., Hope's Htg. & Lighting, Ltd., London, England.	J. J. Fraser *J. W. Cooling	W. G. Case *M. H. Jones
COLLINS, JOSEPH A., Mgr., Frontier Engrg. Corp., Buffalo, N. Y.	S. M. Quackenbush Joseph Davis	M. C. Beman D. J. Mahoney
CUMMINGS, IRA R., Engr., Westinghouse Elec. & Mfg. Co., Cleveland, Ohio.	J. L. Foley E. C. Smyers	T. F. Campbell F. C. McIntosh
ETIE, W. R., Owner, Sheet Metal Heating, Houston, Texas.	A. B. Banowsky D. S. Cooper	A. M. Chase, Jr. A. F. Barnes
FISHER, BERT P., Owner & Mgr., Southern Furnace & Supply Co., Houston, Texas.	D. S. Cooper A. M. Chase, Jr.	A. B. Banowsky J. A. Walsh
HAPPERFIELD, G. J., Director, Chandos Engineering Company, Ltd., London, W. 1, England.	Walter G. Case *Thomas E. Barnes	*R. G. Crittall *J. R. Kell
HOGER, BURTON E., Staff Engr., Basic Magnesium, Inc., Las Vegas, Nev.	A. J. Hess Leo Hungerford	J. B. Griffith C. G. Hokanson
JOHANNESEN, RALPH C., Mech. Engr., Giffels & Vallet, Inc., Detroit, Mich.	E. F. Hyde R. S. M. Wilde	*G H. Whybrew *C. H. Baker
JONES, HUBERT L., Mech. Engr., W. W. Ahlschlager & Assoc., Dallas, Texas. *(Reinstatement and Advancement)*	T. H. Anspacher C. Rollins Gardner	Leslie S. Gilbert Marvin L. Brown
KAZLOUSKAS, ANTHONY, Jr. Mech. Engr., Wilbur Watson & Associates, Cleveland, Ohio.	C. F. Eveleth L. H. Pogalies	E. W. Gray R. A. Wilson
KEGARISE, RALPH R., Mech. Engr., Koppers Co., Pittsburgh, Pa.	H. C. Sharp James Barry, Jr.	E. B. Cover C. R. Davis
KELL, WALDO R., Vice-Pres., The Marley Co., Inc., Kansas City, Kans. *(Reinstatement and Advancement)*	L. T. Mart E. K. Campbell	W. L. Cassell N. W. Downes
KERR, ROBERT, Gen. Mgr., Universal Sheet Metals, Ltd., Toronto, Can.	G. C. Kemp V. J. Jenkinson	S. A. Jennings R. S. Mathison
KETCHUM, E. R., Engineer, The Marley Company, Inc., Kansas City, Kans.	Leon T. Mart Harold W. Stanton	Donald D. Williams Max G. Lehman
LEE, JAMES A., Mgr., Contract Dept., Kelvinator Div., Nash-Kelvinator Corp., Detroit, Mich. *(Advancement)*	H. F. Hutzel C. L. Toonder	W. G. Boales A. E. Knapp
LEWIS, VELMA I., Secy.-Treas., Dwight Oil Heat, Albany, N. Y.	H. F. Lewis G. A. Teeling	H. A. Bond C. E. Hunziker
LUNT, WILBUR F., Fuel Oil Consultant, O.P.A., Boston, Mass.	A. B Fels *G. A. Partridge	*H. J. Higgins *L. J. Nisbet
MILWARD, ROBERT K., Br. Mgr., U. S. Radiator Corp., Detroit, Mich. *(Advancement)*	J. F. McIntire G. D. Winans	W. H. Old F. J. Feely
NICHOLS, HAROLD R., Engr., Healy Plbg. & Htg. Co., Minneapolis, Minn.	L. L. Hyde Allan Paine	F. C. Winterer Wm. McNamara
NIEMOELLER, ARTHUR R., Mfrs. Repr., St. Louis, Mo.	L. R. Szombathy M. F. Carlock	G. B. Rodenheiser E. E. Carlson

NIESKE, GEORGE F., Supt. of Const., C. N. Flagg & Co., Inc., Meriden, Conn.

PATTERSON, RALPH A., Sales Mgr., Bell & Gossett Co., Morton Grove, Ill.

POUJADE, JAMES V., Chief, Refrigeration Unit, R & U Branch, Hq. Fourth Service Command, Atlanta, Ga.

ROBINSON, CLAUDE A., Owner, Robinson Radiant Heat, Detroit, Mich.

RUBEL, HARRY L., Owner, Rubel & Jensen Co., Newark, N. J.

SCHAMPEL, HOWARD B., Plb. & Htg. Supt., Al Johnson Const. Co., New York, N. Y.

SCHOERNER, RUDOLPH T,, Chief Engr. & Production Mgr., Taco Heaters, Inc., Providence, R. I.

STONE, A. A., Manager, Dallas Branch Mundet Cork Corporation, Dallas, Texas.

VIA, CLARENCE W., Mech. Engr., Black & Veatch, Kansas City, Mo.

YOUNG, CHESTER C., Utilization Engr., Lone Star Gas Co., Dallas, Texas.

ZANONE, HENRY A., Supt., Plbg. & Htg., Commonwealth of Kentucky, Frankfort, Ky.

*Non-member.

Winfield Roeder	H. R. Briggs
L. A. Teasdale	J. R. Smak
W. W. Lige	H. A. Lockhart
R. E. Moore	C. E. Pullum
W. P. Sherman	L. F. Lawrence, Jr.
W. P. Oster	L. L. Barnes
M. B. Shea	E. F. Hyde
W. C. Randall	R. F. Connell
J. C. Miles	W. T. Jones
L. B. Ray	E. H. Morgan
E. J. Gossett	R. E. Moore
J. C. Matchett	A. O. May
R. L. Blanding	H. A. Essley
R. E. Daly	M. F. Blankin
C. R. Gardner	J. A. Ray
W. H. Moler	L. C. McClanahan
H. L. Stevens	Gustave Nottberg
H. H. Wright	N. N. Rivard
W. H. Moler	E. T. Gessell
L. S. Gilbert	J. A. Ray
*R. P. Whitton	*J. B. Rieman
*P. S. Sinton	*T. E. Van Meter

Candidates Elected

In the past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

ALEXANDER, KEITH O., Sales Engr., Neil H. Peterson Co., San Francisco, Calif.

BONNER, JOHN, Htg. Engr., Dayton Rubber Mfg. Co., Arlington, Mass.

CRANAGE, THOMAS, Sales Engr., Clarage Fan Co., Chicago, Ill. *(Advancement)*

DAHLSTROM, GODFREY A., Mechanical Engr., Smith-Hinchman & Grylls, Detroit, Mich. *(Advancement)*

EARHART, JOE S., Mfg. & Sales Engr., Los Angeles, Calif. *(Reinstatement and Advancement)*

HELFINSTINE, ROY J., Assoc. Mech. Engr., Illinois State Geological Survey, Urbana, Ill.

KAVENY, J. GORDON, Pres., Kaveny Bros. Co., Montclair, N. J.

KEETON, ROBERT W., M.D., Head, Dept. of Medicine, University of Illinois, Chicago, Ill.

KREMER, RICHARD H., Secy., Kupferle-Hicks Htg. Co., St. Louis, Mo.

LUTTRELL, LEE W., Chief Engrg. Draftsman, U. S. Coast Guard Headquarters, Washington, D. C.

MARC, HENRI M., Asst. Dir. of Research, The Philip Carey Mfg. Co., Cincinnati, Ohio.

MCLEOD, CLARENCE H., Application Engr., York Ice Machinery Corp., Dallas, Texas.

PETERSON, B. G., Mfrs. Repr., Omaha, Neb.

PORTER, CARL W., Assoc. Engr., Navy Dept., Bureau of Ships, Washington, D. C.

RICHMOND, K. C., Editor, Coal-Heat, Chicago, Ill.

SIMMONDS, VERNE, Mech. Engr., U. S. Eng. Office, Omaha, Neb.

SINGLETON, ARTHUR B., Chief Engr., Kerr Machinery Co., Detroit, Mich.

ASSOCIATES

CAUHORN, A. V., Owner, A. V. Cauhorn Co., Detroit, Mich.

CHRISTIE, JOHN A., Mfrs. Agt., Waterous Ltd., Brantford, Can.

CRUMP, SAMUEL, Pres. & Mgr., Samuel Crump Co., Ltd., Toronto, Can.

DALTON, R. T., Sales Engr., State Supply Co. Cleveland, Ohio.

EVANS, W. H., Gen. Mgr., Minneapolis-Honeywell Regulator Co., Ltd., Toronto, Can.

GROSSMAN, RALPH, Volcano Ltd., Montreal, Que., Canada.

HEMINGWAY, JOHN C., Jr., H. C. Little Burner Company, Inc., San Rafael, Calif.

LECUREUX, EZRA E., Mech. Engr., Bechtel-McCone-Parson Corp., Birmingham, Ala.

LINDSLEY, FORREST A., Sales, Crane Co., Detroit, Mich.

MOORE, ROBERT E., Archt., Moody and Moore, Winnipeg, Can.

SAUNDERS, DOUGLAS G., John Plaxton Company, Limited, Winnipeg, Man., Can.

SIGGINS, GEORGE S., Mfrs. Agt., East Orange, N. J.

WILLIAMS, E. BRYAN, Laboratory Mgr., The Torrington Mfg. Co., Torrington, Conn.

JUNIORS

DEGILIO, LOUIS, Refrig. Dept., Robert Elder Carriage Works, Toronto, Can.

NOVOLANSKY, S. I., Flight Sergeant (Inspector), Royal Canadian Air Force, Winnipeg, Man., Canada.

ROSER, EDWARD III, U. S. Engineers, Seventh Service Command, Fort Leavenworth, Kans.